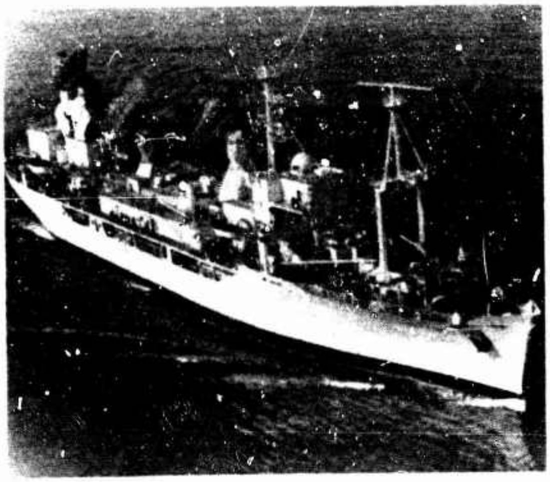
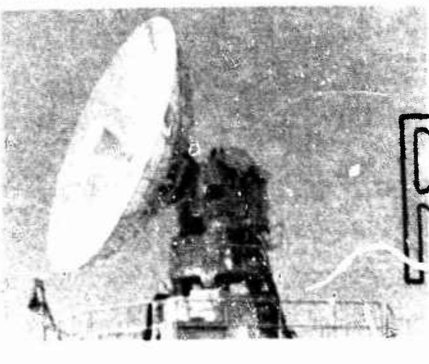
SUPERSEDES ETR-TR-71-5
DATED SEPTEMBER 1971

THE UNITED STATES AIR FORCE EASTERN TEST RANGE

1 JULY 1976



RANGE INSTRUMENTATION HANDBOOK



PATRICK AIR FORCE BASE, FLORIDA

FOREWORD

The purpose of the *Air Force Eastern Test Range (AFETR) Instrumentation Handbook* is to provide detailed descriptions of the instrumentation and related equipment for use by Range personnel and Range Users. It complements the *AFETR Capabilities Handbook* which provides an assessment of the support capabilities of the Eastern Test Range (ETR). These two handbooks should be used together to provide a complete depiction of the ETR.

This handbook will be updated periodically to reflect changes that continually occur. Current data on specific areas of interest will be provided upon request.

FOR THE COMMANDER

HOWARD L. PECKHAM, JR., Colonel, USAF
Director of Range Operations

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER 14 AFETR-TR-76-04	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 The United States Air Force Eastern Test Range. Range Instrumentation Handbook.		5. TYPE OF REPORT & PERIOD COVERED 9 Final rept.,
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 Bruce E. Cone Capt., USAF		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Plans and Requirements Division Directorate of Range Operations (DOX) Hq., Air Force Eastern Test Range Patrick Air Force Base, Florida 32925		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Plans and Requirements Division Directorate of Range Operations (DOX) Hq., Air Force Eastern Test Range Patrick Air Force Base, Florida 32925		12. REPORT DATE 11 1 Jul[redacted]76
		13. NUMBER OF PAGES 173
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Not applicable 12 175p.		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE Not applicable

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Test Range, Radar, Telemetry, Optics, Communications, Command/Control, Range Safety, Range Tracking Ships, Missile Testing, Impact Location Systems, Data Handling/Processing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Air Force Eastern Test Range (AFETR) extends from the eastern United States mainland through the south Atlantic Ocean area eastward into the Indian Ocean. It includes all stations, sites, ocean areas, and air space necessary to conduct missile and space vehicle test and development.

This hand book describes the major instrumentation systems now operating, or being installed, on the ETR. The equipment and operation of each system is discussed briefly, and its location and accuracies given.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

1B

AFETR-TR-76-04

Range Instrumentation Handbook

1 July 1976

United States Air Force
Eastern Test Range
Patrick Air Force Base, Florida

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ABBREVIATIONS

ABR	Airborne Bistatic Receiver Subsystem
AC	aircraft
ac	alternating current
A/D	analog to digital
ADRAM	advanced digital range machine
AFB	Air Force base
afc	automatic frequency control
AFETR	Air Force Eastern Test Range
AF&F	Arming, Fusing and Firing (system)
A/G	air to ground
agc	automatic gain control
a-m	amplitude modulation
AMR	Atlantic Missile Range (obsolete)
AMR-FR 1400	recorder/reproducer
AN/AMQ-9	radiosonde
AN/FPQ-6	Missile Precision Instrumentation Radar (MIPIR)
AN/FPQ-13	modified AN/FPS-16 radar
AN/FPQ-14	modified MIPIR
AN/FPQ-15	precision space track radar
AN/FPS-16	precision tracking radar
AN/FPS-16V	modified AN/FPS-16 shipboard radar
AN/FPS-26	high-power transmitter used on AN/FPS-16V radar
AN/FPS-77	weather radar
AN/GMD-4	rawin set (weather system)
AN/GMQ-11	wind measuring set
AN/GMQ-13A	cloud height set
AN/SPS-35	search radar used for Range clearance
AN/SSQ-41	sonobuoy
ANT	Antigua
AN/TMQ-5	radiosonde recorder
AN/TPQ-18	Missile Precision Instrumentation Radar (MIPIR)
APT	automatic picture transmission
APW-11	radar beacon
ARIA	Advanced Range Instrumentation Aircraft
ARIS	Advanced Range Instrumentation Ship
ASC	Ascension
ASD	Aeronautical Systems Division
ASN	acquisition-stabilization network
ASPS	Acoustic Ships Positioning System
ASW	antisubmarine warfare
AT&T	American Telephone and Telegraph Co.
AT-36	60-ft telemetry antenna
Auxtrack	auxiliary angle tracking
AWSP	Air Weather Service Publication
Az	azimuth
BC-4	ballistic camera
BCD	binary-coded decimal
BET	best estimate of trajectory
BOA	broad ocean area
BRN-3	navigation system
b/s	bits per second

BW	bandwidth
CCAFS	Cape Canaveral Air Force Station
CCC	Central Control Console
CCFF	Cape Canaveral Forecast Facility
CCTV	closed-circuit television
CDC-3100	RTCS computer
CDC-3600	RTCS computer
CDCE	Central Data Conversion Equipment
CDP	Central Data Processing
CDPS	Central Data Processing System
CDS	Command Destruct System
CEC	Consolidated Electrodynamics Corp
CFAR	constant false alarm rate
CL	common language
cm	centimeter
COMM	communications
CRDSB	central retransmission decommutator and storage
CRT	cathode-ray tube
CSE	circular standard error
CSM	central switch matrix
cw	continuous wave
CZR	a type of ribbon-frame camera
D/A	digital to analog
DAC	digital to analog converter
DARTS	Digitized Automatic Radar Tracking System
DAT	designate, acquisition, and track
dB	decibels

dBm	decibels referenced to 1 milliwatt
dc	direct current
DCC	Designate Control Console
DMSP	data conversion interface and switching equipment
deg	degree(s)
DEMUX	demultiplex
DME	distance measuring equipment
DMSP	Defense Meteorological Satellite Program
DOD	Department of Defense
DP	distribution programmer
DPE	data processing equipment
DPDE	digital playback and digitizing equipment
DPN-66	radar beacon
DPS	Data Processing Subsystem
DRS	Digital Range Safety (System)
DRSB	digital recording system buffer
DRSS	Downrange Support Ship
DSOC	DRSS Safety Officer Console
DSSB	data selector and storage buffer
EC-135	ARIA airframe
E,F,G	Earth-centered rectangular coordinates
$\dot{E},\dot{F},\dot{G}$	E,F,G rates
El	elevation
EPABX	electronic private automatic branch exchange
ESCO	manufacturer
ETR	Eastern Test Range
FCA	frequency control and analysis
FEDAC	forward error detection and correction

F&G	Felton & Gixlleume
fm	frequency modulation
f/s	frame per second
ft/s	feet per second
FSK	frequency shift keying
FSO	Flight Safety Officer
GBI	Grand Bahama Island
GBR	timing standard (Rugby, England)
GDOP	geometric dilution of precision
GEOS-C	geodetic satellite
GET	ground elapsed time
GHz	gigahertz
GMT	Greenwich Mean Time
GTK	Grand Turk
hf	high frequency (3-30 MHz)
HF/SSB	high frequency/single sideband
HOR	horizontal
IBM 360/65	postflight data processor
IBM 7094	postflight data processor
ICBM	intercontinental ballistic missile
ID	identification
i-f	intermediate frequency
IFLOT	intermediate focal length optical telescope
IGOR	intercept ground optical recorder
IIR	integrated instrumentation radar (ARIS)
IIR-C	5400-5900 MHz integrated instrumentation radar
IIR-L	1270-1290 MHz integrated instrumentation radar
IIR-U	435.39 MHz integrated instrumentation radar
IP	impact point, position impact prediction
in/s	inch per second
IR	infrared
IRIG	Inter-Range Instrumentation Group
IRV	interrange vector
IT&T	International Telephone and Telegraph Co.
K	Kelvin (degrees absolute) (degree symbol understood)
k	kilo (thousand)
K-19B	ballistic camera
kb/s	thousand bits per second
kHz	thousand hertz
KSC	Kennedy Space Center
kVA	thousand volt-amperes
kW	kilowatts
kyd	1,000 yards
LASS	Launch Area Support Ship
LCP	left circular polarization
LCU	landing craft-utility
lf	low frequency (30-300 kHz)
LHC	left-hand circular polarization
l/min	lines per minute
Lorac	long-range accuracy (system)
Loran-C	long-range navigation (system)
LPLWS	Launch Pad Lightning Warning System
LSB	least significant bit
mA	milliampere
max	maximum
MCC	Master Control Console
mf	medium frequency (300-3000 kHz)

mfc	manual frequency control
MHz	megahertz
MFID	main frame identification
MILA	Merritt Island (obsolete)
MILS	Missile Impact Location System
min	minimum, minute
MIPIR	Missile Precision Instrumentation Radar
MITTS	Mobile IGOR Tracking Telescope System
MM	millimeter
MOD II	small tracking radar (modified SCR-584)
MOIS	Missile Operations Intercom System
MOTS	Mobile Optical Tracking System
MPDL	maintenance program designation letter
mrad	milliradian
MRD	Mechanized Range Documentation
MRS	Mechanized Range Scheduling
MSC	Military Sealift Command
MSC	Master Systems Console
MSL	mean sea level
ms	millisecond
M-32	Mincom intermediate band recorder
MTU	magnetic tape unit
MUSTRAC	multiple target steerable telemetry tracker
MW	megawatt
NA	not applicable
NASA	National Aeronautics and Space Administration
NAV	navigation
NBA	timing standard (Balboa, Panama)
ND	neutral density
NDHIS	Navigation Data Handling Interface System
nmi	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Air Defense Command
NRZ	nonreturn to zero
NRZ-L, -M, -S	nonreturn to zero -level, mark, space
OCC	Operations Control Center
OT&E	operational test and evaluation
P-3 Orion	Navy ASW aircraft
PA	public address (system)
PACM	pulse-amplitude code modulation
PAM	pulse-amplitude modulation
PB	program block
PCM	pulse-code modulation
PDM	pulse-duration modulation
PDS	Projection Display System
PEC	Program Entry and Control
pH	measure of acidity
pm	phase modulation
POPS	Precision Optical Pedestal System
post-D	post detection
PPI	plan position indicator
p/s	pulses per second
PRE	Pretoria
pre-D	predetection

PRF	pulse-repetition frequency
PSK	phase shift keying
RA	range amplitude
rad	radians
RAMLAS	RML laser
RC-5, RC-5A-	fixed metric camera systems
RCC	Range Control Center
RCE	Receiving Control Equipment
RCP	right circular polarization
RCS	radar cross section
rcvr	receiver
R&D	research and development
RDAU	radar data analysis unit
rf	radio frequency
RICS	Range Instrumentation Control System
RIS	Range Instrumentation Ship
RML	Range Measurements Laboratory
r/min	revolution per minute
rms	root mean square
ROSE	meteorological balloon
ROTI	Recording Optical Tracking Instrument
RP	retransmission programmer
RSDS	Range Safety Display System
RSO	Range Safety Officer
RTCS	Real-Time Computer System
RTI	range time intensity
RTTDS	Real-Time Telemetry Data System
RV	reentry vehicle
RZ	return to zero
s	second
SAMSO	Space and Missile Systems Organization
SAMTEC	Space and Missile Test and Evaluation Center
SCR-584	basis for the Mod II Radar
SFID	subframe identification
SGLS	Space Ground Link Subsystem
shf	super high frequency (3-30 GHz)
SINS	Ships Inertial Navigation System
SIM	Ships Instrumentation Manager
SIT	silicon intensified tube
SMILS	Sonobuoy Missile Impact Location System
S/N	signal-to-noise (ratio)
sofar	sound fixing and ranging
SPAC	signal programmer and conditioner
SPAMS	Ships Position and Attitude Measurement System
SRN-9	navigation system
SS/FM	single sideband/frequency modulation
SSBAM	single sideband amplitude modulation
SSPO	Strategic Systems Project Office (Navy)
STAFFMET	staff meteorologist
starute	a parachute type device
STC	Standard Telephone & Cable
T-0	time of launch
TAA-2	85-ft telemetry antenna
TAA-3	30-ft telemetry antenna
TAA-3A	33-ft telemetry antenna

TAA-8/8A	80-ft telemetry antenna
TAA-9	17-ft telemetry antenna (Redstone)
TACAN	Tactical Air Navigation (System)
TACSAT	Tactical Communications Satellite
TAER	time, azimuth, elevation, range
T-AGM 9	USNS Arnold
T-AGM 10	USNS Vandenberg
T-AGM 20	USNS Redstone
TAM-1	broadbeam telemetry antenna
TASS	terminal area support ship
TDM	time division multiplex
TDMTDS	Time Division Multiplexer Timing Distribution System
Tel 4	ETR Central Telemetry Facility
TKDC-1	Manually Programmed Time Division Multiplex (system)
TKM-1	telemetry remote signal recorder subsystem
TLM	telemetry
TMM-7	telemetry tape copy subsystem
TOM	Technical Operations Manager (ARIS)
TOPS	Transistorized Operations Phone System
TOY	time of year
TRAP	Terminal Radiation Program (aircraft)
TRKI-12	telemetry receiver/recorder group
TTR	target tracking radar
TTY	teletype
TV	television
TVOC	Television Operations Center
TWT	traveling-wave tube
uhf	ultra high frequency (300-3000 MHz)
USB	Unified S-band
USN	US Navy
USNS	US Naval Ship
UTC	Universal Time Coordinated
UV	ultraviolet
V ac	volts, alternating current
V dc	volts, direct current
Vert	vertical
vhf	very high frequency (30-300 (MHz)
vlf	very low frequency (3-30 kHz)
VOR/ILS	Navigation System
VWS	Vertical Wire Skyscreen
W	watts
WECO	Western Electric Co.
WINDS	Weather Information Network and Display System
w/min	words per minute
w/s	words per second
WWV	Timing Standard Station
WWVH	Timing Standard Station (Hawaii)
WWVL	Timing Standard Station (Boulder, Colorado)
XDS	Xerox Data Systems
xmtr	transmitter
X	power/(optical)
XY	two orthogonal axes
XY Bldg	ETR Communications Center
XYZ	three orthogonal axes
$\dot{X}\dot{Y}\dot{Z}$	XYZ rates
yd	yard(s)
@	About
μ	micro
μF	microfarad
μs	microsecond

SECTION 1
INTRODUCTION

The Eastern Test Range (ETR) is a National Range managed by the Air Force for the Department of Defense. It was built and is used primarily for missile and space vehicle tests. However, it is also used for some aircraft, drone, helicopter, balloon, and small rocket tests. It extends from Cape Canaveral Air Force Station eastward to 90°E longitude in the Indian Ocean (figures 1-1 and 1-2). The Range comprises a series of stations located at Cape Canaveral and on the Florida mainland; on the islands of Grand Bahama, Grand Turk, Antigua, and Ascension; and at Pretoria, South Africa. These stations are augmented with a fleet of instrumented aircraft and ships. In addition to these stations, the ETR can use instrumentation operated by the National Aeronautics and Space Administration (NASA) at Bermuda and Wallops Island.

The ETR is a service-oriented organization whose basic mission is to collect, process, and deliver test-related data to Range Users. In supporting a typical test, the ETR collects metric, telemetry, photographic, acoustic, and meteorological data, and when requested performs processing, reduction, and analysis of the data to the user's specifications.

The technical personnel and the sophisticated instrumentation at the ETR have provided test support to a variety of systems ranging from man-launched anti-tank weapons to the largest ICBM systems, manned lunar program, and interplanetary probes.

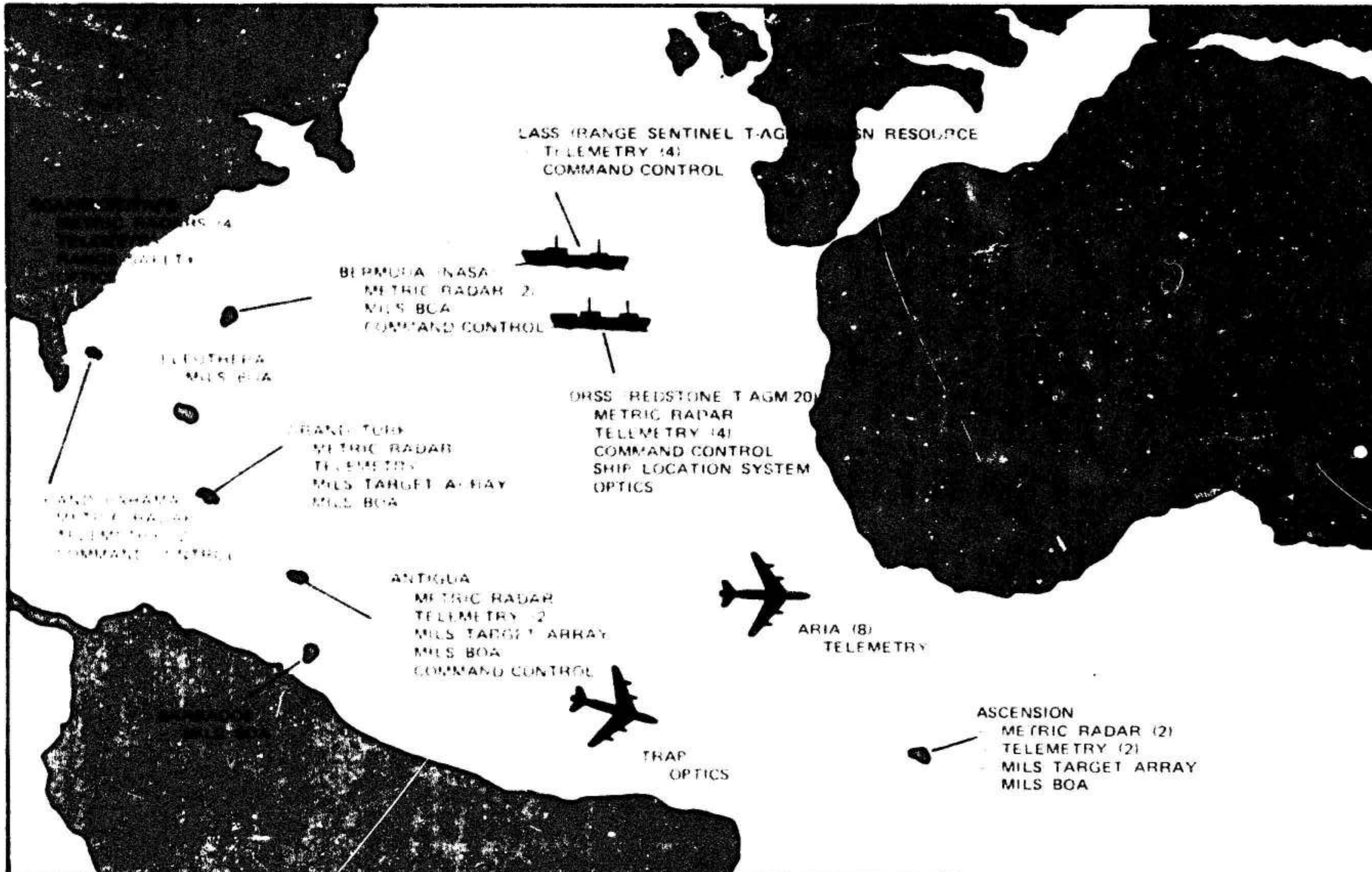
The ETR is fully equipped to serve as a "lead range" in a worldwide network, and also to support other lead ranges. This ability is established by using the comprehensive communications, timing, and command systems on the Range, together with the Real-Time Computer System (RTCS) located at Cape Canaveral. The ETR staff includes Range and network management specialists to coordinate these activities.

1.1 METRIC MEASUREMENT CAPABILITIES

Precision-tracking pulse radars are located at Merritt Island, Cape Canaveral, Patrick Air Force Base (AFB), Grand Bahama Island, Grand Turk Island, Antigua, and Ascension. All of these radars are capable of either beacon or echo tracking, and all are able to transmit precision data at 10 samples per second to the RTCS. In addition, the Cape is equipped with a tracking radar which is suitable for targets such as an aircraft or drone operating in the vicinity of the Cape. Shipboard radars provide both metric and signature data gathering capability.

Metric optics capability is available at Cape Canaveral and all downrange stations of the ETR and aboard ships. These systems include precision theodolites, ballistic cameras, and long-range, large-aperture telescopes. The ballistic cameras and theodolites are mobile, and may be positioned in a variety of configurations to provide favorable geometry for various flight profiles.

Missile Impact Location Systems (MILS), which are useful in testing many types of missiles, are installed at several locations in the Atlantic Ocean. One form of MILS is an array of hydrophones called target arrays on the ocean bottom, connected to a nearby shore station. Such systems are installed near Grand Turk (about 700 nmi from the Cape), near Antigua (about 1,300 nmi from the Cape), and near Ascension (about 4,400 nmi from the Cape). Another form of this system is called the Sonobuoy MILS or SMILS. This system consists of bottom-mounted transponders, and an array of expendable surface sonobuoys dropped in the water by an aircraft. The other form of this system, called the broad ocean area (BOA) MILS, consists of hydrophones suspended in the ocean at or near the sound fixing and ranging (sofar) axis at strategic locations around the Atlantic basin.



CCAFS	–	Cape Canaveral Air Force Station	LASS	–	Launch Area Support Ship
KSC	–	Kennedy Space Center	DRSS	–	Downrange Support Ship
MILS	–	Missile Impact Location System	ARIA	–	Advanced Range Instrumentation Aircraft
BOA	–	Broad Ocean Area	TRAP	–	Terminal Radiation Program Aircraft

Figure 1-1. Eastern Test Range Baseline Configuration

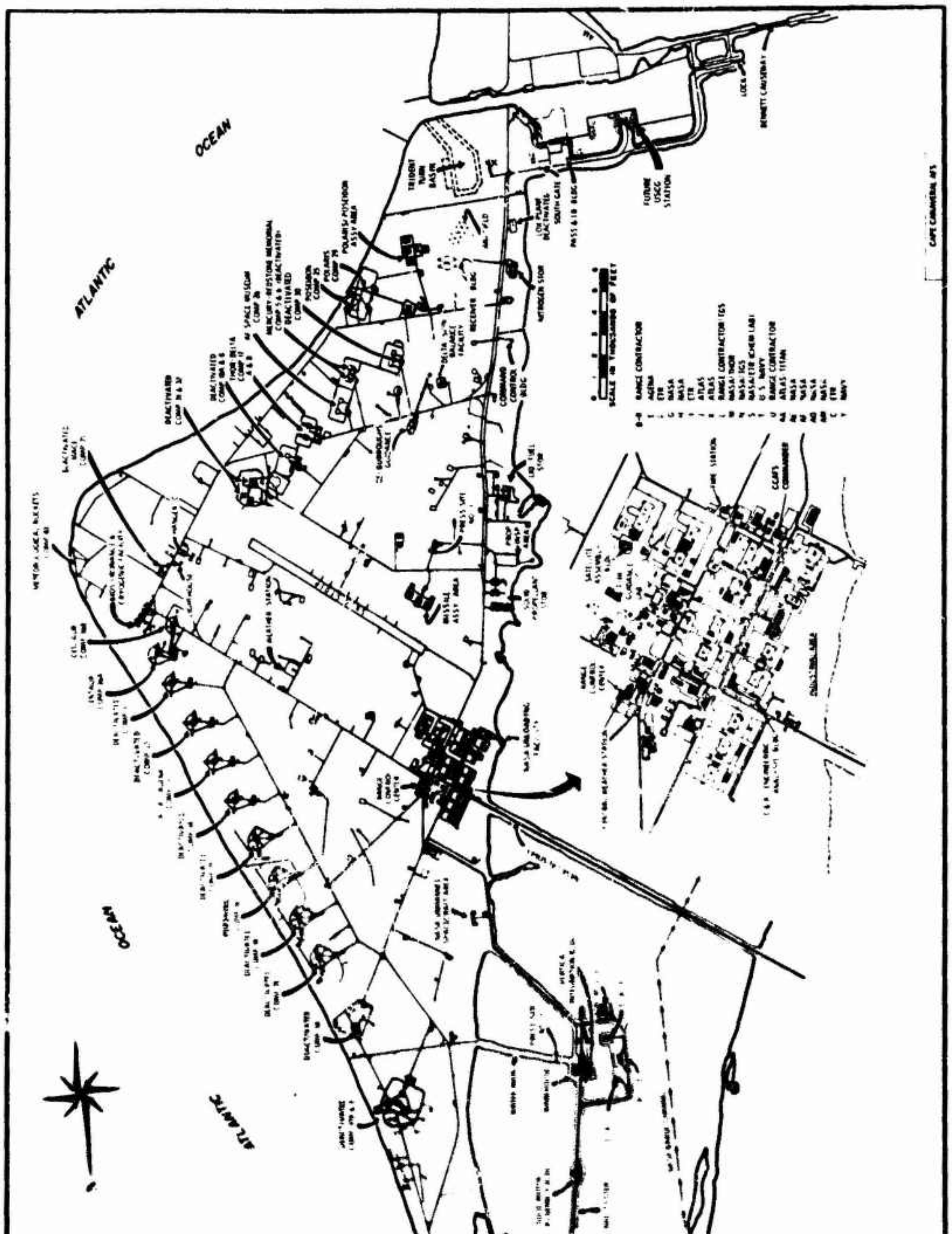


Figure 1-2. Map of Cape Canaveral Air Force Station

1.2 TELEMETRY CAPABILITIES

The ETR telemetry capability consists of a large central station at the Cape and several fixed stations downrange. In addition, the fleet of Advanced Range Instrumentation Aircraft (ARIA) and the USNS Redstone, and Advanced Range Instrumentation Ships (ARIS) may be positioned in areas not covered by fixed stations, from which they can collect, record, and relay telemetry data. Tracking stations are located at the Cape, Grand Bahama, Grand Turk, Antigua, Ascension, and Pretoria, and are equipped with one or more large-aperture antennas, multiple receivers, and real-time retransmission equipment. Other antennas having lower gains are installed at some stations. Current equipment provides reception of frequencies in the range of 100 to 4000 MHz (depending on the location).

1.3 SIGNATURE CAPABILITIES

The signature capabilities on the ETR are divided into two categories: radar cross-section and opto-radiometric. Radar cross-section data can be obtained at Ascension and on-board the Advanced Range Instrumentation Ships (ARIS). Opto-radiometric data are collected primarily on the ARIS. Signature data can be made available at any ETR station if required.

1.4 COMMAND/CONTROL

The ETR Command/Control System provides the ability to transmit user commands to missiles and spacecraft and to permit arm-and-destruct commands by Range Safety. Transmitters are located at Cape Canaveral, Grand Bahama, and Antigua and on-board the USNS Redstone.

1.5 PHOTOGRAPHIC SERVICES

The ETR is staffed and equipped to collect engineering sequential and documentary photographic data in essentially all areas of the Range. This capability, together with the metric optics systems, is complemented by a photo processing facility that can provide finished data to users quickly and by a complete set of photographic data reduction devices.

1.6 METEOROLOGICAL SERVICES

The ETR is equipped to collect, process, and deliver meteorological data from a full spectrum of instruments throughout the Range. Coverage is provided from the surface to approximately 300,000-ft altitude at various stations and on ships. Climatological data for the ETR is contained in the *ETR Meteorological Handbook*, and additional data may be obtained from the Staff Meteorologist.

1.7 LABORATORY SERVICES

The ETR operates a number of laboratories whose services are provided to Range Users. Using standards traceable to the National Bureau of Standards, these laboratories calibrate instruments for the Range and for Range Users. Calibration capability exists in the fields of ac/dc voltage and current, resistance, capacitance, inductance, frequency, and radio frequency (rf) and nuclear radiation.

Services and standards are also provided in the fields of dimensional measurement, temperature, humidity, vacuum/pressure, mass, weight, force, flow, optics, light, acoustics, vibration, time, torque rate, volume, specific gravity, hardness, leak detection, combustible gas detection, oxygen analysis, hydrogen and halogen detection, pH measurement, and spectrophotometry.

1.8 FACILITIES

A substantial amount of missile assembly, hangar, and administrative floor space and other facilities are available in the launch area for Range Users. These facilities are accessible by land, sea, and air. Water accessibility is gained from the ocean by way of Port Canaveral and by way of the Intercoastal Waterway. Air access to the launch area is gained by a runway on the Cape, which can accommodate any aircraft now in use.

SECTION 2
DATA ACQUISITION

2.1 RADAR

Precision-tracking pulse radars are located at Cape Canaveral Air Force Station, Merritt Island, Patrick AFB, Grand Bahama, Grand Turk, Antigua, Ascension, and on board the three Range Instrumentation Ships. All of these radars are capable of either beacon or echo (skin) tracking, and all can transmit precision data at 10 samples per second to the RTCS. In addition, the Cape is equipped with a 2700 to 2900-MHz tracking radar which is suitable for a target such as an aircraft or drone operating in the vicinity of the Cape. Shipboard radars provide both metric and signature data gathering capability.

When required, the NASA-owned AN/FPQ-6 radars at Bermuda Island and at Wallops Island, Virginia, support AFETR tests.

Radars provide most of the metric data acquired on the ETR. They are augmented in the launch area with optics to obtain more accurate data when the distances are short, and for radar calibration, and in the terminal area with the MILS arrays Their locations, identifiers, and technical characteristics are summarized in the tables which follow.

2.1.1 On-Axis Radars (AN/FPQ-13, -14, -15)

The "on-axis" concept grew out of a need to steer telescopes having extremely narrow fields of view with a smoothness and accuracy adequate to permit definitive photography of satellites in orbit. Conventional monopulse radars are not capable of tracking without random lags and jitter about the target, and consequently cannot produce data of sufficient quality to steer a telescope so that its optical axis always passes through the target.

The on-axis concept depends for its success on the principle that a short segment of any trajectory may be approximated by a segment of an orbit. This can be accomplished by driving the radar antenna with data that originate in a synthetic orbit generator operating in a computer. The orbit generator permits the coefficients of its orbital equations to be adjusted in real-time in response to target behavior as sensed by the tracking portion of the radar, thus closing the tracking loop via the computer. Adjustments to the orbital equations are made automatically, at intervals and in increments that adapt themselves to optimize the antenna drive signals for the particular dynamics of the target being tracked. In addition, all deterministic characteristics of the radar antenna are programmed in the computer and are used to compensate the antenna drive signals. As a result for targets whose accelerations are not large, the "axis" of the antenna is maintained precisely on the target.

To implement the on-axis concept at a radar, a computer is inserted in the antenna servo loops. With its associated software, the computer manages the antenna in real-time. Digital encoders are connected to the antenna azimuth and elevation shafts, and the responses of the mount to the computer-generated drive functions are sampled for processing in the computer. The smallest encoder increment determines the precision to which mount response can be measured, and for a 20-bit encoder is about one millionth of a circle (5.6 microradians or 1.24 seconds of arc). This precision, together with 100 updates per second of the antenna drive signals, makes it possible to point to a star and follow it across the sky without visible jitter when viewed by the antenna-mounted telescope and displayed on the console by the closed-circuit television (TV) subsystem. By this method, the telescope, encoders, and mount alignment; zero set or bias; mislevel; nonorthogonality; and droop can be established. An optical calibration reference can then be established on the antenna mount. Availability of targets with both optical and radar visibility then permits determination of the rf axis. This process results in an accurately calibrated radar. The computer and its associated software compensate for the modeled errors and gain coefficients (some of which are functions of angle rates and, therefore, must be determined in real-time), and point the antenna at the tracked vehicle. The encoders report these angles to the computer, which outputs the cor-

TABLE 2-1. AFETR RADARS – LOCATIONS, ELEVATION, IDENTIFIERS

Radar Type	Prototype (If Any)	Station	Location Latitude (N)	Location Longitude (E)	Elevation (MSL) (meters)	ETR Identifier
AN/FPQ-13	AN/FPS-16	Patrick AFB, FL	28.227322°	279.39371°	14.33	0.13
AN/FPQ-14	AN/FPQ-6	Patrick AFB. FL	28.2264°	279.4005°	14.94	0.14
AN/FPQ-14	AN/TPQ-18	Merritt Isl, FL	28.4247°	279.3354°	11.25	19.18
AN/FPS-16		Cape Canaveral	28.4816°	279.4233°	13.64	1.16
AFETR Mod II	SCR-584	Cape Canaveral	28.4929°	279.424386°	17.33	1.5
AN/FPQ-13	AN/FPS-16	Grand Bahama	26.6156°	281.652°	14.91	3.13
AN/FPQ-14	AN/TPQ-18	Grand Turk	21.4626°	288.8678°	36.00	7.14
AN/FPQ-14	AN/FPQ-6	Antigua	17.1436°	298.2073°	42.30	91.14
AN/FPQ-15	TTR ***	Ascension	−7.9067°	345.5973°	39.51	12.15
AN/FPS-16		Ascension	−7.9514°	345.5877°	92.34	12.16
AN/FPS-16V	AN/FPS-16	USNS Redstone				20.16
IIR-C*		One on ea ARIS				
IIR-L*		One on ea ARIS				
IIR-U*		One on ea ARIS				
AN/FPQ-6**		Bermuda	32.3479°	295.3465°	21.10	67.18

*Two-of-a-kind shipboard radars.
**Property of National Aeronautics & Space Administration
***Nike Zeus

rected data in an Earth-centered (E,F,G) coordinate set.

Modifications required for the on-axis modification include long focal-length boresighting optics, precision (20-bit) angle encoders, a high-speed digital computer, and software. Other hardware and software modifications are generally made when the radar is being converted; however, they are not essential to the on-axis design. Typical of these other changes are new range machines, solid-state receivers, and solid-state angle servo subsystems.

At present, there are two on-axis radars at Patrick AFB, and one each at Merritt Island, Grand Bahama, Grand Turk, Antigua, and Ascension.

AN/FPQ-13 RADAR

TABLE 2-2. AN/FPQ-13 RADAR TECHNICAL CHARACTERISTICS

Radar Type	
Current designation	AN/FPQ-13
Prototype	AN/FPS-16 AN/FPS-26 (transmitter)
Transmitter	
Frequency range	5.4-5.9 GHz
Pulse repetition frequency(PRF)	160 p/s (pulses per second)
Peak power	5 MW
Pulse coding	Capable of two pulse codes – 3 μs to 9 μs
Pulse width	1 μs, 5.0 μs
Receiver	
Frequency range	5.4-5.9 GHz
Bandwidth	2 ±0.2 MHz for 1 μs pulse width; 200 ±20 kHz for 5 μs pulse width
Noise figure/ temperature	2 dB - paramps on; 11 dB – paramps off
Sensitivity	-120 dBm
Dynamic range	80 dB
Antenna	
Diameter	20 ft
Type	Parabolic dish
Polarization	Vertical
Gain	47.5 dB
Beamwidth	0.6 degrees
Pedestal Angle Servos	
Azimuth slew rate	42°/s
Elevation slew rate	25°/s
Azimuth track rate	29°/s
Elevation track rate	21°/s
Range Tracking	
Nonambiguous range	4092 nmi

Slew rate . . . . 82 kyd/s

Acceleration . . . . 20 kyd/s²

Tracking rate . . . . 20 kyd/s

Accuracy

Specific . . . . See AFETR Accuracy Bulletin for official values.

Acquisition Aids

Range and angle search patterns are computer controlled. Processor and constant false alarm rate (CFAR) circuits are provided for target identification.

Data Inputs

Data Characteristics

Input data: 1-speed synchro data for azimuth and elevation; IRV (Interrange Vector) NORAD (North American Air Defense Command) Message; X,Y,Z low density data; look angles.

Output data: 2-speed synchro data for azimuth and elevation E,F,G,T 10-p/s data or TAER (time, azimuth, elevation, and range) 10-p/s data

X,Y,Z low density data

Teletype (TTY) 100 w/min
- B3 format
- 38-character format
- IRV

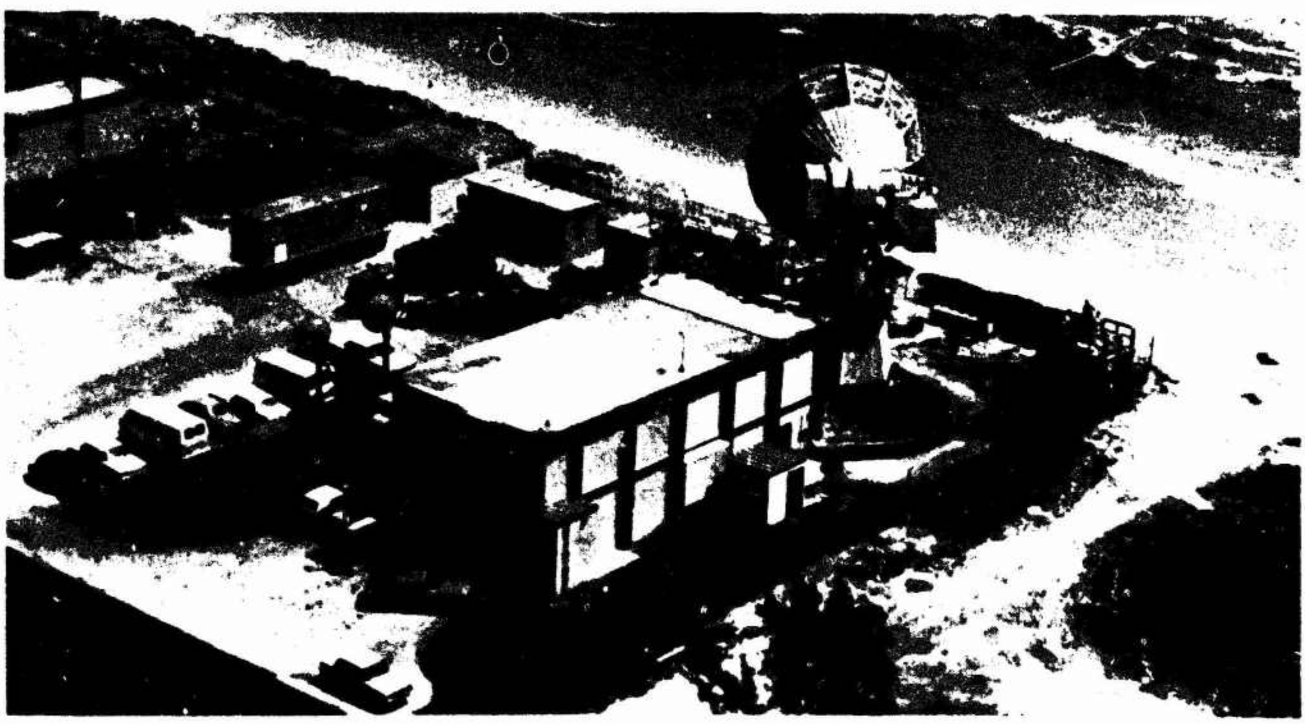
The system also has a 2400-b/s data link for radar designation.

TABLE 2-3. AN/FPQ-14 RADAR TECHNICAL CHARACTERISTICS

Radar Type

Current designation AN/FPQ-14

Prototype AN/FPQ-6



AN/FPQ-14 RADAR

Transmitter

Frequency range	5400-5900 MHz
Frequency stability	Less than 100 kHz/hr drift
Fine tuning	Plus or minus 20 MHz
PRF	160, 640 p/s
Peak power	2.8 MW
Average power (max)	4.8 kW
Power programming range	25 dB
Pulse coding	Code A and B (1-3 pulses)
Pulse width	0.25, 1.0, 2.5, and 5.0 μs

Receiver

Frequency range	5400-5900 MHz
Frequency stability	Skin: 1 kHz relative to transmitter Beacon: 300 kHz/24 hr in manual frequency control (MFC)
Bandwidth	4 MHz (1 μs), 400 kHz (2.5 μs), 200 kHz (5 μs)
Noise figure/ temperature	150 K (cooled paramp) (above 10° elevation)
Dynamic range	70 dB

Antenna

Diameter	29 ft
Type	Parabolic
Polarization	Vertical, linear, and circular
Gain	53 dB
Beamwidth	0.38°
Mount	Elevation over azimuth
Feed	Cassegrainian

Pedestal Angle Servos

Azimuth slew rate	500 mrad/s
Elevation slew rate	500 mrad/s
Azimuth track rate	350 mrad/s
Elevation track rate	350 mrad/s
Azimuth acceleration	350 mrad/s²
Elevation acceleration	350 mrad/s²

Range Tracking

Nonambiguous range	32,000 nmi
Slew rate	160 kyd/s
Acceleration	600 yd/s/s
Tracking rate	20 kyd/s

Precision

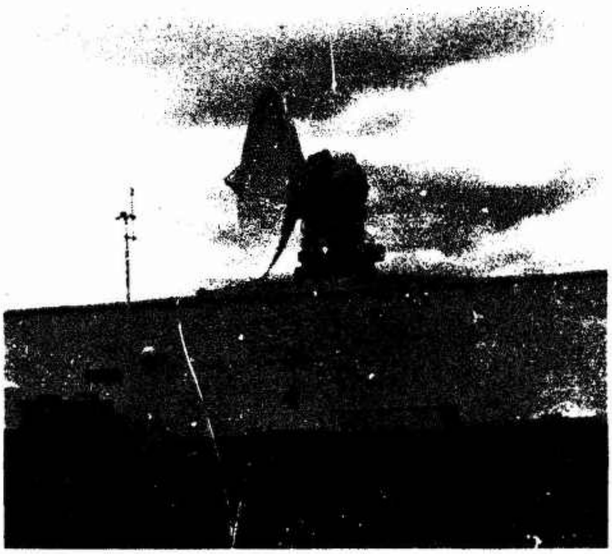
Range	23 bits (least significant bit (LSB) = 0.97 yd)
Angles	20 bit (LSB = 0.006 mrad)

Accuracy

Specific	Refer to AFETR Accuracy Bulletin

Data Inputs

Synchro	
Azimuth	1:1, 60 Hz
Elevation	1:1, 60 Hz
Digital	2400 b/s, E,F,G, $\dot{E},\dot{F},\dot{G}$,T
Other	100 w/min TTY, E,F,G, $\dot{E},\dot{F},\dot{G}$,T



AN/FPQ-15 RADAR

TABLE 2-4. AN/FPQ-15 RADAR TECHNICAL CHARACTERISTICS

Radar Type	
Current designation	AN/FPQ-15
Transmitter	
Frequency range	5.5 to 5.9 GHz
PRF	160 p/s
Peak power	5 MW
Average power (max)	8 kW
Pulse coding	3 to 9 μs
Pulse width	1 or 10 μs
Receiver	
Frequency range	5.4 to 5.9 GHz
Bandwidth(s)	80 kHz, 1 MHz
Noise figure/temperature	3 dB with paramps
Sensitivity	-120 dBm
Dynamic range	95 dB
Antenna	
Diameter	28-ft
Type	Parabolic
Polarization	Vertical – transmit; horizontal – receive
Gain	48 dB
Beamwidth	8 mrad (0.45°)
Feed	Cassegrainian
Pedestal Angle Servos	
Azimuth slew rate	500 mrad/s
Elevation slew rate	350 mrad/s
Azimuth track rate	500 mrad/s
Elevation track rate	350 mrad/s
Azimuth acceleration	500 mrad/s²
Elevation acceleration	400 mrad/s²
Range Tracking	
Nonambiguous range	4096 nmi
Slew rate	82 kyd/s
Acceleration	20 kyd/s²
Tracking rate	20 kyd/s
Precision	
Range	23 bits (LSB = 0.97 yd)
Angles	20 bits (LSB = 0.006 mrad)
Data Inputs	
Synchro	
Azimuth	1:1, 60 Hz
Elevation	1:1, 60 Hz
Digital	2400 b/s, E,F,G, Ė,Ḟ,Ġ,T
Other	100 w/min – TTY, E,F,G, Ė,Ḟ,Ġ,T

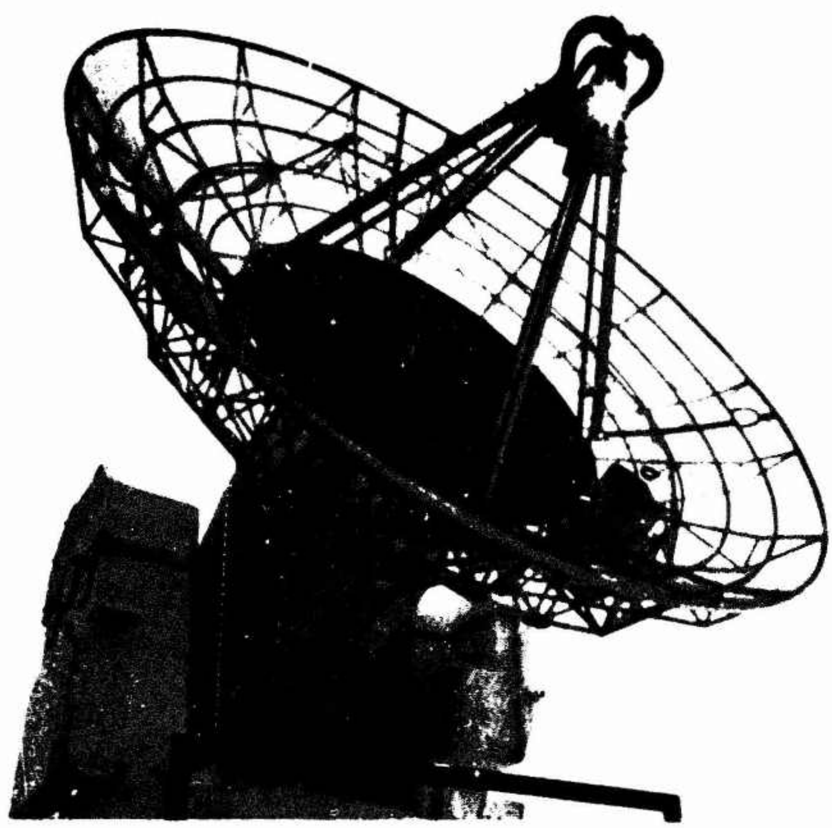
2.1.2 AN/FPS-16 Radar

The AN/FPS-16 is a high-precision, monopulse tracking radar designed specifically for missile tracking.

Output power is transmitted through microwave components to a 4-horn feed which, with the reflector, produces a narrow beam. The transmitted signal may be either single pulse, for skin track, or coded pulse, for beacon track. The return rf signal is received by the 4-horn group and fed to an rf comparator which, by vectorial addition of energy received at selected pairs (horizontal and vertical), develops azimuth and elevation error signals representing the target's displacement from the beam centerline. The vectorial sum of the energy from all four horns furnishes a reference signal. The error signals are channeled to separate tracking sections, converted to a 30-MHz i-f signal, amplified, and compared with the reference signal. The phase relationships determine the error direction and the amplitude indicates the error magnitude. The error signals are detected, commutated, and used to control the antenna positioning servos.

An output of the reference channel is applied to the range tracking section to generate the voltage that positions the range data takeoff equipment. Receiver channels are gated in range so that only signals for the target being tracked are supplied to the rest of the equipment. The range tracking section delivers slant range data to the digital section and to the console for presentation.

Data takeoff in all three polar coordinates is in digital, synchro, and potentiometer form. The range, azimuth, and elevation encoders generate Gray code outputs. A Gray-to-binary conversion is made before data are transmitted and recorded. Range and angle digital data output is in straight binary form, when transmission is required, with least significant digit first (20 bits in range and 17 bits in angles).



AN/FPS-16 RADAR

TABLE 2-5. AN/FPS-16 RADAR TECHNICAL CHARACTERISTICS

Radar Type

Current designation	AN/FPS-16

Transmitter

Frequency range	5480-5825 MHz
PRF	71, 80, 142, 160, 285, 320, 341, 366, 640 p/s
Peak power	1 MW
Average power (max)	640 W
Power programming range	30 dB
Pulse coding	Capable of 3 pulse codes
Pulse width	0.25, 0.5, 1.0 μs

Receiver

Frequency range	5450-5825 MHz
Bandwidth(s)	1.8 MHz or 8.0 MHz
Noise figure/temperature	4 dB
Sensitivity	-107 dBm at 2 MHz; -101 dBm at 8 MHz
Dynamic range	80 dB with agc (automatic gain control)

Antenna

Diameter	12 ft
Type	Parabolic reflector
Polarization	Cape FPS-16: linear/vertical; Ascension FPS-16: circular
Gain	44 dB
Beamwidth	1.2°
Mount	Elevation over azimuth
Feed	4-horn monopulse, Newtonian focus

Pedestal Angle Servos

Azimuth slew rate	45°/s
Elevation slew rate	24°/s
Azimuth track rate	42°/s
Elevation track rate	22.5°/s
Azimuth acceleration	31°/s/s
Elevation acceleration	31°/s/s

Range tracking

Acceleration	2,000 yd/s/s
Tracking rate	12,000 yd/s

Precision

Range	20 bits; LSB = 1 yd
Angles	17 [illegible]ts; LSB = 0.0488 mrad

Accuracy

Nominal

Range (beacon)	25 ft
Azimuth (beacon)	0.2 mrad
Elevation (beacon)	0.2 mrad

Specific . . . . . See *AFETR Accuracy Bulletin*

Acquisition

1. ±3000-yd range sweep
2. Angle sector scans
3. Angle circular scans

Data Inputs

Synchro

Range	60 Hz; 1:1
Azimuth	1:1
Elevation	1:1

Data Outputs

1. Analog X,Y,Z, in which ±140 V dc = 10^6 yd

2. Digital time, azimuth, elevation, and range (TAER); 10 samples per second; transmitted over a unique data transmitter to the Cape Real-Time Computer for general purpose use.

Power Requirements

120/2?? V, 60 Hz, 4-wire grounded neutral, 150 kVA (75 kVA for radar, 75 kVA for air conditioning)

2.1.3 Integrated Instrumentation Radar (IIR)

The ARIS IIR is an integrated radar system composed of (1) two independent tracking radars, one at 5400 to 5900-MHz, the other at 1270 to 1290-MHz which provide tracking and target signature (cross-section) data and (2) a slaved uhf radar which provides signature data only. In the 5400 to 5900-MHz band, signature data are collected on two polarizations, along with cross-polarization data, while target tracking is carried out by the vertically polarized channel. In the 1270 to 1290-MHz band, a horizontally polarized channel is used for both tracking and signature data.

The antenna for the 5400 to 5900-MHz system is a 30-ft diameter parabolic reflector having both horizontal and vertical polarization capabilities. A hyperbolic subreflector is used in a Cassegrainian configuration; it is reflective to horizontally polarized signals but transparent to vertically polarized signals. The vertical feed is located at the focal point and transmits through the Cassegrainian subreflector. The 5400 to 5900-MHz tracking radar employs a vertically polarized monopulse feed located at the parabola focal point for developing angle tracking information on skin or beacon targets. Its antenna includes an auxiliary 4-ft dish for side lobe blanking. The tracker can provide precise skin track of targets when the target signal-to-noise ratio is 12 dB or greater and provide early acquisition, long-range track on beacon targets. Digital range units provide unambiguous data up to 32,000 nautical miles with a range resolution of ±2 yards.

The range data supplied to the computer is a 25-bit binary word. Deck angle data is derived from 19-bit digital shaft encoders which are mounted on the elevation and train axes of the mount.

The 5400 to 5900-MHz radar can track a skin or beacon return from a primary target and provide relative range and angle data on additional targets by means of postflight data reduction techniques. The secondary target must be within the track cell of the radar, i.e., within ±0.2° in angle and ±32,000 yards in range of the primary target. In addition, the secondary target must be separated in range from the primary target by at least 100 yards. Target slant range resolution of 100 yards is accomplished through pulse compression. A skin pulse of 30 μs is compressed to less than 1 μs in the receivers before angle error and signature data are extracted.

The 5400 to 5900-MHz radar can acquire a target by using designate data supplied by the 1270 to 1290-MHz radar, telemetry tracker, star tracker, MK-51 director, or intermediate focal length telescope (IFLOT); by the computer using the theoretical orbital elements; or by local radar console operation of handwheels. The computer is the primary source of designate and acquisition data. A scan pattern is superimposed upon the designate point to enhance the probability of acquisition. Early target acquisition is enhanced by the simultaneous beacon interrogation mode (selectable), allowing interrogation pulses from both the horizontal and vertical channels at the same time. A video double threshold detector provides a 99.9 percent probability of detection of targets having a signal-to-noise ratio of 10 dB or greater.

In addition to target tracking, the 5400 to 5900-MHz radar provides target illumination for cross-section data. Horizontally and vertically polarized energy at a peak power of 1 MW is transmitted by interlaced pulses. Each polarization uses a PRF or 160 p/s. Both normal and cross-polarized returns are received and recorded.

The 1270 to 1290-MHz antenna on each ship is a 40-ft diameter parabolic dish with a Cassegrainian feed for horizontally polarized transmission and reception. It operates as an independent tracking radar providing both metric and signature data. The radar tracks in the skin mode only. Peak power output is 8 MW, PRF 160 p/s, and the pulse width is 30 μs compressed to 0.6 μs at 4 dB. The

radar employs a 32,000-nmi unambiguous digital range machine which provides 25-bit digital range with a resolution of ±2 yards. The radar can track one target during mission time and record video data on all targets seen within the track envelope, which is defined as within +48 nmi, -16 nmi of the primary target in range and within the 1.3° beamwidth of the radar.

The uhf (435-MHz) radar aboard the Arnold and Vandenberg tracks in range only. This system shares the 40-ft antenna with the 1270 to 1290-MHz radar. Peak power output is 5.6 MW for vertically polarized transmission. The radar is used to gather signature data on targets being tracked by the 1270 to 1290-MHz radar. The radar can operate at a PRF of 160 p/s, either 30 or 300 μs pulse width, and is equipped with pulse compression. PRF's of 960, 1120, 1280, 1440, and 1600 μs with a 30 μs pulse width are available for coherent wake data acquisition. The uhf feed is a radome covered pyramidal focal horn. Vertically polarized uhf signals emitted by the horn pass through the subreflector and are radiated into space. Reception of uhf signals is the reverse of the transmission process.

Radar data are recorded by the ship's data handling subsystem for postflight processing at the AFETR. Metric data are recorded in digital form and consist of antenna train and elevation position referenced to the deck plane of the ship and slant range to the target. Peak detected (or box car) video is digitized in real-time and recorded along with the metric data to provide prime target signature data.

Raw video data are recorded on video tape with the necessary reference information for postflight processing. These data provide both amplitude and angle error information on secondary targets with the radar beamwidth and range cell. Amplitude information relates to the target radar cross-section and is a prime factor in determining target signature. Angle error information relates to target position within the radar beam and is needed to determine the true level of the reflected radar signal.

TABLE 2-6. IIR-C RADAR TECHNICAL CHARACTERISTICS

Radar Type

Current designation	ARIS IIR (5400-5900 MHz)

Transmitter

Frequency range	5400-5900 MHz
Frequency stability	1 part in 10^9 per day
PRF	160 p/s (see note)
Peak power	1,000 kW
Average power (max)	4.9 kW
Pulse coding	1 to 3 pulse coding, 1 to 11 μs spacing
Pulse width, skin	30 μs
beacon	1 μs

Receiver

Frequency range	5400-5900 MHz
Bandwidth	500 MHz
Noise figure/ temperature	Cooled paramp 80 K – uncooled 350 K
Sensitivity	-112 dBm @ 0 dB S/N
Dynamic range	60 dB instantaneous

Antenna

Diameter	30 ft
Type	Parabolic dish
Polarization	Linear/horizontal and vertical
Gain	52.5 dB (5.4 to 5.6 GHz), 53 dB (5.6 to 5.9 GHz)
Beamwidth	0.4°
Mount	Elevation over train (azimuth)
Feed	Horns – monopulse

Pedestal Angle Servos

Train slew rate	35°/s

Elevation slew rate . . . . 26°/s

Train track rate . . . . 35°/s

Elevation track rate . . . . 26°/s

Acceleration . . . . 28°/s/s

Range Tracking

Nonambiguous range . . . . 32,335 nmi

Slew rate . . . . 200,000 yd/s

Acceleration . . . . 5,000 yd/s/s

Tracking rate . . . . 20,000 yd/s

Precision

Range . . . . 25 bits (LSB = 2 yd)

0.001° (derived from synchro) 19 bits (LSB = 0.012 mrad)

Accuracy

Specific . . . . . See *AFETR Accuracy Bulletin*

Acquisition Aids

Angle scans

Auxiliary range tracker

Video digital detector

Computer designate

Slave bus

Data Outputs

Digital az and el, Analog az and el, Digital range . . . 10 p/s

Radar cross-section (RCS) on tracked target, pulse by pulse

Radar video tape

Relative range & RCS

On-off axis targets in the radar beam/look interval

All the above data are both horizontally and vertically polarized.

Cross polarization signals are also recorded.

Range time intensity (RTI) and range amplitude (RA) from video tape.

NOTE

Dual transmitters; each operates at 160-p/s PRF, one transmitting horizontally polarized energy, the other transmitting vertically polarized energy; transmissions are interlaced.

TABLE 2-7. IIR-L RADAR TECHNICAL CHARACTERISTICS

Radar Type

Current designation . . ARIS (Advanced Range Instrumentation Ship) IIR (1280 MHz)

Transmitter

Frequency range . . . . 1270-1290 MHz

Frequency stability . . . . 1 part in 10^{10} per day

Fine tuning . . . . . ±10 MHz about 1280 MHz

PRF . . . . 160 p/s (nominal)

Peak power . . . . 10 MW

Average power (max) . . . . 48 kW

Pulse width . . . . 30 μs

Receiver

Frequency range . . . . 1270-1290 MHz

Bandwidth . . . . 5 MHz

Noise figure/temperature . . . . 1.5 dB

Sensitivity . . . . 60 dB instantaneous

Dynamic range . . . . 120 dB with attenuation

Antenna

Diameter	40 ft
Type	Parabolic dish
Polarization	Linear/horizontal
Gain	41 dB
Beamwidth	1.2°
Mount	Elevation over train
Feed	Horn/Cassegrainian

Pedestal Angle Servos

Train slew rate	35°/s
Elevation slew rate	26°/s
Train track rate	35°/s
Elevation track rate	26°/s
Train acceleration	28°/s²
Elevation acceleration	28°/s²

Range Tracking

Nonambiguous range	4,000 nmi
Slew rate	200,000 yd/s
Acceleration	1,500 yd/s
Tracking rate	20,000 yd/s

Precision

Range	22 bits (LSB = 1.953 yd)
Angles	19 bits (LSB = 0.012 mrad)

Accuracy

Specific	See *AFETR Accuracy Bulletin*

Acquisition Aids

Angle Scans

Auxiliary range tracker

Video digital detector

Computer designate

Slaved bus

Data Outputs

Horizontal polarized tracked target azimuth, elevation, and range.

RCS

2-inch video tape nontracked target relative azimuth, elevation, and range and RCS from video tape playback RA and RTI film from video playback.

TABLE 2-8. IIR-U RADAR TECHNICAL CHARACTERISTICS

Radar Type

Current designation	ARIS IIR (435.39 MHz)

Transmitter

Frequency	435.39 MHz
Frequency stability	1 part in 10^{10} per day
Fine tuning	None
PRF	160, 960, 1120, 1280, 1440, and 1600 p/s
Peak power	5.6 MW
Average power (max)	274 kW
Pulse widths	30 or 300 µs

Receiver

Frequency	435.39 MHz
Bandwidth	5 MHz (3 dB)
Sensitivity	See Note 1

Antenna (Note 2)

Diameter . . . . 40 ft

Type . . . . Parabolic dish

Polarization . . . . Linear/vertical

Gain . . . . 31.5 dB

Beamwidth . . . . 3.5°

Mount . . . . Elevation over train

Feed . . . . Horn/focal point

Pedestal Angle Servos – (shares IIR-L pedestal)

Data Outputs

Vertical polarized tracked target and adjacent gates (30 total), 100-yd intervals, phase and amplitude, each gate, and relative range (based on IIR-L), 2-in video tape

Relative range and resolution (corrected for beam position if target appears in IIR-L beam and has IIR-L S/N >20 dB)

NOTES

1. -98 dBm @ S/N = 4 dB in noncoherent mode
   -108 dBm @ S/N = -6 dB in doppler mode

2. Shares antenna pedestal and main reflector with the 1270 to 1290-MHz radar.

2.1.4 AN/FPS-16V Radar

The USNS Redstone's radar system consists of a modified AN/FPS-16 system with an additional selectable AN/FPS-26 high power transmitter, and an advanced digital range machine (ADRAM). The radar is configured to provide trajectory data during near-Earth orbits and transfer orbit insertion of beacon-carrying spacecraft, or to skin track reentry bodies of low radar cross-section in the reentry and impact areas.

The antenna is a 16-ft parabolic reflector with a Cassegrainian multimode feed, capable of radiating and receiving from 5400 to 5900 MHz and with an antenna gain of 46 dB in the sum channel. The group includes on-mount rate gyros for antenna stabilization. The pedestal is an elevation-over-azimuth two-axis system, rotating on hydrostatic bearings compensated for horizontal thrust components, with an electrohydraulic drive. The rf head is located in the upper pedestal behind the feed assembly and contains i-f preamplifiers, phase shifters, duplexer couplers, waveguide tuners and switches, and afc (automatic frequency control) controls.

The transmitter group consists of an AN/FPS-26 transmitter (3 MW peak power), an AN/FPS-16 transmitter (1 MW peak power), common microwave components, and appropriate interfacing between the two transmitters. Pulse width and beacon/skin mode controls are provided at the console, subject to limitations of the individual transmitters. Pulse width of the FPS-26 transmitter is selectable at 1, 5, or 10 μs. No beacon coding capability is provided on this transmitter. Pulse width of the FPS-16 transmitter is fixed at 1 μs. The latter transmitter has a beacon tracking capability with selectable coding and automatic beacon sequencing. The PRF is fixed at 160 p/s for both transmitters.

The receiver subsystem covers a frequency range of 5400 to 5900 MHz. Simultaneous reception of both skin and beacon targets is provided. In addition to the three receiver channels required for monopulse tracking, the radar uses an ungated video channel for console display, and to feed the digital range tracking and auxiliary tracking systems.

The range tracking subsystem is an all-electronic ADRAM which utilizes *n*th-time-around techniques. In effect, targets can be tracked at ranges in excess of the radar time base by a multiple-time-around method, rather than by the reduction of the radar pulse repetition frequency. The range tracking subsystem is divided into two parts. One, the range subsystem, is capable of deriving continuous, unambiguous range tracking data on suitable targets to a maximum range of 32,000 nmi. The other, the Auxtrack subsystem, provides automatic angle acquisition and track of targets which may be either beacon returns due to

interrogation by the local or distant radar, or skin returns from the local radar.

Three modes are selectable to acquire a target. In the manual mode, the antenna is stabilized, and movement to acquire the target is accomplished by the use of handwheels. Analog scan patterns, generated by the Auxtrack subsystem, can be used to aid acquisition. In the synchro mode, pointing data is derived from the acquisition-stabilization network (ASN). Analog scan patterns may also be used. The ASN normally drives pointing information from other on-board sensors. In the digital designate mode, pointing and stabilization data are derived from the Central Data Processing System (CDPS) based on nominal and/or in-flight trajectory information. Digitally developed scan patterns may be overlaid on the designate data.

Radar-boresight camera film and films from cameras photographing an amplitude-vs-range A-scope and an intensity-vs-range scope are also available for postflight analysis.

TABLE 2-9. AN/FPS-16V RADAR TECHNICAL CHARACTERISTICS

<u>Radar Type</u>

Current designation AN/FPS-16V

Prototype AN/FPS-16

<u>Transmitter</u>

Frequency range . . . . 5400-5900 MHz

PRF . . . . 160 p/s

Peak power . . . . . 1 MW or 3 MW (see Note)

Pulse widths . . . . . . 1.0 μs @ 1 MW; 1.0, 5.0, 10.0 μs @ 3 MW

<u>Receiver</u>

Frequency range . . . . 5400-5900 MHz

Antenna

Diameter . . . . 16 ft

Gain . . . . 46 dB

Mount . . . . Elevation over azimuth

<u>Range Tracking</u>

Nonambiguous range . . . . 32,000 nmi

<u>Accuracy</u>

Specific . . . . . See *AFETR Accuracy Bulletin*

<u>Acquisition Aids</u>

1. Auxtrack
2. Various scan patterns
3. Synchro from acquisition stabilization network

<u>Miscellaneous</u>

Antenna pedestal includes rate gyros for motion stabilization.

NOTE

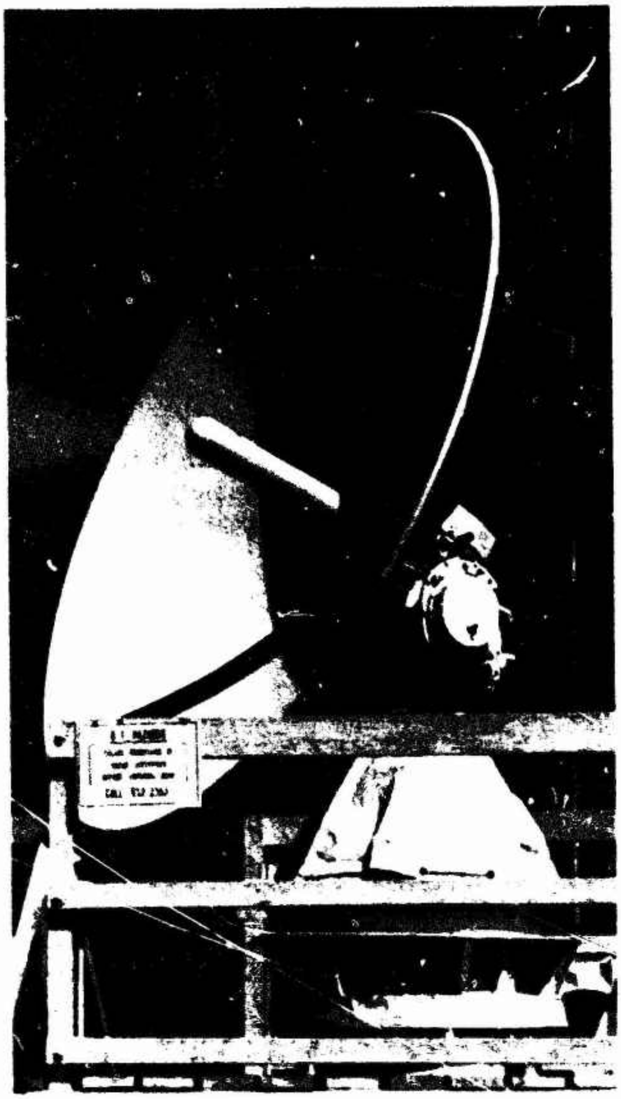
Radar is equipped with a selectable AN/FPS-26 transmitter having 3-MW peak power, in addition to the standard 1-MW FPS-16 transmitter.

2.1.5 Mod II Radar

The Mod II is a SCR-584 radar, which has been extensively modified and improved. It is an autotracking radar, and can operate in both beacon and echo modes. It operates in the frequency range of 2700 to 2900 MHz, and provides outputs consisting of range, azimuth angle, and elevation angle, in both digital and synchro form; by use of an analog coordinate converter, it provides X, Y, and Z outputs in the form of dc voltages.

Angle servo drive signals are derived from the feed assembly which nutates at 30 revolutions per second. Range tracking is performed in a conventional early/late-gate equi-signal range machine. Digital data outputs are generated by encoders which are sampled at a rate of two times per second.

The Mod II can provide unambiguous line-of-sight coverage on beacon-equipped targets to a distance of 400 nmi. Its echo range is 40 nmi on a 1-square meter target at 0 dB S/N ratio.



MOD II RADAR

TABLE 2-10. MOD II RADAR TECHNICAL CHARACTERISTICS

Radar Type

Current designation . . . . Mod II

Prototype SCR-584

Transmitter

Frequency range . . . . 2700-2900 MHz

PRF . . . . 205 to 1707 p/s

Peak power . . . . 250 kW

Average power (max) . . . . 341.4 W

Pulse width . . . . 0.8 μs

Receiver

Frequency range . . . . 2650-2950 MHz

Bandwidths . . . . 3 MHz

Noise figure/temperature . . . . 13 dB

Sensitivity . . . . -96 dBm

Antenna

Diameter . . . . 10 ft

Type . . . . Parabolic dish

Polarization . . . . Vertical or horizontal

Gain . . . . 37 dB

Beamwidth . . . . 2.5° unlobed; 4.8° @ 50% crossover, 3.8° @ 80%

Mount . . . . Elevation over azimuth

Feed . . . . Nutating, 30 Hz, 50% or 80% crossover

Pedestal Angle Servos

Azimuth slew rate . . . . 120°/s

Elevation slew rate . . . . 60°/s

Azimuth track rate . . . . 20°/s

Elevation track rate . . . . 20°/s

Range Tracking

Nonambiguous range . . . . 400 nmi

Tracking rate . . . . 8 kyd/s

Precision

Range . . . . 1.0 yd

Angles . . . . 0.005°

Accuracy (nominal)

	Random	Systematic
Range (beacon)	100 ft (400 nmi)	45 ft
Range (skin)	100 ft (90 nmi)	45 ft
Azimuth (beacon)	2 mrad	1 mrad
Azimuth (skin)	2 mrad	1 mrad
Elevation (beacon)	2 mrad	1 mrad
Elevation (skin)	2 mrad	1 mrad

Accuracy

Specific . . . Refer to *AFETR Accuracy Bulletin*

Acq tion Aids

Manual from optical coordinate converter

Boresight TV director

Data Inputs

Synchro . . . . 1:1 and 36:1, 60 Hz

Data Outputs

1. Analog X,Y,Z, in which ±140 V dc = $\pm 10^6$ yd
2. Punched paper tape containing time, azimuth, elevation, and range (TAER) azimuth and elevation LSB = 0.005°, range LSB = 1 yd; 2 samples/second
3. Synchro azimuth, elevation, range
   a. Azimuth and elevation @ 1:1 and 36:1; 60 Hz
   b. Range @ 1:2,000 yd, 1:50 kyd, $1:10^6$ yd; 60 Hz

Power Requirements

115 V ±10% 3-phase ungrounded delta, 12 kVA

Miscellaneous

Will detect a 1 square-meter target to 40 nmi at 0 dB S/N ratio.

Minimum tracking S/N is 12 dB.

2.1.5 AN/SPS-35 Radar

The SPS-35 is a conventional search radar used to scan off-shore waters for range safety. It is located on Cape Canaveral and is dedicated to the Range clearance application.

TABLE 2-11. AN/SPS-35 RADAR TECHNICAL CHARACTERISTICS

Radar Type

Current designation AN/SPS-35

Transmitters

Frequency range . . . . 9375 MHz

PRF . . . . 1500/750 p/s

Peak power . . . . 7 kW

Pulse width . . . . 2 μs

Receiver

Frequency range . . . . 9375 MHz

Bandwidth . . . . 10 MHz

Antenna

Beamwidth . . . . . . 2° horizontal 15° vertical

Mount . . . . Continuous/20 r/min (avg) rotation in azimuth plane

2.2 TELEMETRY

2.2.1 Introduction

The ETR land telemetry facilities include the central telemetry station (Tel 4) located on Merritt Island, four essentially similar downrange stations, and a semiactive station at Pretoria, South Africa. These land-based facilities are augmented by the USNS Redstone, which is especially equipped to serve as a support ship for US Navy underwater launched missiles, the two ARIS, and the eight ARIA aircraft.

Table 2-12 is a tabulation of major equipment by location. Figure 2-1 is an abbreviated block diagram of a typical telemetry receiving station. One or more groups of the equipment represented by the blocks are installed at each station. In addition, the central telemetry station at Merritt Island has capabilities for acquisition, storage, processing, preparation of computer-formatted magnetic tapes, tape copying, tape playback, and interface for video retransmission. Four separate display areas are equipped with direct-write pen recorders, oscillograph recorders, and digital displays for the convenience of Range Users. Computer-ready magnetic tapes may be formatted in real-time or from recorded data tapes. Facilities are provided to produce duplicate predetection or video magnetic tapes. Interconnection of the data handling system is largely accomplished by remotely controlled switches rather than through the use of manual patch panels. In addition to switch closures, the Control, Status Display, and Patching System provides equipment status signals and remote operation of the station data recorders.

2.2.1.1 Antennas and Rf Distribution Systems

Autotracking antenna subsystems are distributed as shown in table 2-12. The 80-ft-diameter TAA-8's, installed in 1968, are the newest of the antenna systems on the Range. The TAA-8, TAA-3, and the USNS Redstone antennas are equipped with 2200 to 2300-MHz feeds and parametric amplifiers. The others have a broader frequency capability. The Range Modernization Program provides a Xerox Data Systems (XDS) 530 computer for acquisition, antenna management, test, and calibration for the TAA-3, TAA-8, TAA-8A, and TAA-2 antenna subsystems. New parametric amplifiers and multicouplers have been added to the TAA-2, TAA-3, TAA-8A, and the Tel 4 TAA-3A, which give them the capability to collect either 2200 to 2300-MHz data or down-converted data.

2.2.1.2 Receive and Record

All of the telemetry stations are equipped with one or more TRKI-12 receive and record groups. Each has 12 receivers; two 7-track, ½-in, 1.5-MHz bandwidth tape recorders (some 14-track, 1-in models are available at Tel 4); and associated display units, combiners, converters, amplifiers, and test equipment. Thirty dual-channel receivers and eight 14-track, 1-in, 2.0-MHz tape recorders are available to increase the system capability for receiving and recording 2200 to 2300-MHz data.

2.2.1.3 Separation and Display

Decommutation equipment for pulse code modulation (PCM), pulse amplitude modulation (PAM), and pulse duration modulation (PDM) signals is installed at all of the stations. Three types of decommutators are available: Type I, which can process a PCM, PAM, or PDM IRIG (Inter-Range Instrumentation Group) standard bit stream; Type II, which can process only PCM bit streams, but which has greater PCM versatility than the Type I; and Type III, which can handle only PAM and PDM signals. Frequency modulation (fm) discriminators, digital-to-analog (D/A) and analog-to-digital (A/D) converters, and formatters are available for processing this type of modulated signal for presentation on the analog and digital displays and for computer processing. Displays are conventional pen and oscillograph paper recorders, digital and meter readouts, and cathode-ray tube displays.

2.2.1.4 Real-Time Telemetry Transmission

The ETR is equipped with a real-time data selection and reformatting system that outputs selected words at a lower bit rate to accommodate communications channel bandwidth limitations.

TABLE 2-12. MAJOR TELEMETRY EQUIPMENT

Land Stations

Subsystems	Diameter (ft)	Tel 4	GBI	GTK	ANT	ASC	PRE(1)	Mobile TLM Van
Antenna								
TAA-2	85	–	1	–	–	–	–	–
TAA-3	30	–	–	–	–	1	–	–
TAA-3A	33	1	1	–	1	1	–	–
TAA-8/8A	80	–	–	1	1	–	–	–
AT-36	60	–	–	–	–	–	1	–
Broadbeam	–	2	–	–	–	2	–	3
Receive/Record								
TRKI-12		12/10/3(2)	12/6/10	24/6/0	8/6/0	12/4/0	6/2/0	8/1/1
Receiver System		12/4(3)	8/0	–	6/2	4/2	–	–
Receiver (Dual Ch)		–	–	–	–	3	–	–
Separation								
Decommutator PCM, PAM, PDM (TDM-I)		4	2	2	3	2	2	1(4)
PCM (TDM-II)		3	1	–	–	–	–	–

TABLE 2-12. MAJOR TELEMETRY EQUIPMENT (Continued)

Land Stations (Continued)

Subsystems	Tel 4	GBI	GTK	ANT	ASC	PRE(1)	Mobile TLM Van
PAM/PDM (TDM-III)	2	–	–	–	1	1	–
Discriminator, Fm	36	10	–	18	36	28	26
Discriminator, Fm, Tunable	4	–	–	3	10	2	1
Digital-to-analog (D/A)	450	50	–	50	50	50	10
Analog-to-digital (A/D)	2	1	–	1	1	1	–
Computer Formatter	1	–	–	–	–	–	–
Display							
Recorders (Pen/Osc)	25/32	1/0	1/0	2/2	4/1	5/0	1/0
Magnetic Tape Evaluation	1	–	–	–	–	–	–
Tape Copy (Pre-D/Post-D)	1	–	–	–	–	–	–
Real-Time Telemetry	1	1	1	1	1	–	–

Ships & Aircraft

Subsystems		Redstone	Arnold	Vandenberg	ARIA [8 each]
Antennas	Diameter				
Dish (TAA-9)	17 ft	4	–	–	–
	30 ft	–	1	1	–
	7 ft	–	–	–	1 (ea)
	40 in	–	1	1	–

TABLE 2-12. MAJOR TELEMETRY EQUIPMENT (Continued)

Ships & Aircraft (Continued)

Subsystem	Redstone	Arnold	Vandenberg	ARIA [8 each]
Dipole/Array	–	–	–	3 (5)
Horn	–	2	2	–
Log Periodic	–	1	1	–
Helix/Spiral	–	2	2	–
Receive/Record				
TRKI-12 Receivers	2	1	1	7 data/4 tracking (6)
Separation				
Decommutator				
TDM-I	2	–	–	–
TDM-II	–	1	1	–
EMR 2746	–	–	–	1
Discriminators				
Fm (Fixed)	12	–	–	2
Fm (Tunable)	18	–	–	–
D/A Converter	50	–	–	2
A/D Converter	1	–	–	–
Displays				
Recorders (Pen/Osc)	5/4	6 (7)	6	1-18 channel
Real-Time Transmission	1	–	–	4 (8)

TABLE 2-12. MAJOR TELEMETRY EQUIPMENT (Continued)

NOTES

(1) Inactive; on call-up status.

(2) Receivers/1/2-in tape recorders/1-in tape recorders.

(3) Dual-channel receivers/2 MHz, 14-channel tape recorders.

(4) PCM, EMR Model 2746.

(5) Each ARIA is equipped with a 4-element dipole array for autotracking and reception of 225 to 260-MHz signals. A 136-MHz dipole array is also available, nonautotracking. A 400-MHz dipole array is also available, nonautotracking. All three antenna systems are mutually exclusive, i.e., only one can be operational for one mission.

(6) Receivers may be apportioned to various frequencies as required. Recorders are 1.5 MHz.

(7) 4 each 1-in – 14 track; 2 each 1/2-in – 7 track; all 400 Hz – 1.5 MHz.

(8) Two each 2090-2300 MHz (data & voice); 1 each 225-315 MHz (data & voice); 1 each 225-400 MHz (satellite data relay).

ANT	Antigua	GTK	Grand Turk	PDM	Pulse duration modulation
ASC	Ascension	PAM	Pulse amplitude modulation	TDM	Time division multiplex
GBI	Grand Bahama	PCM	Pulse code modulation	TLM	Telemetry

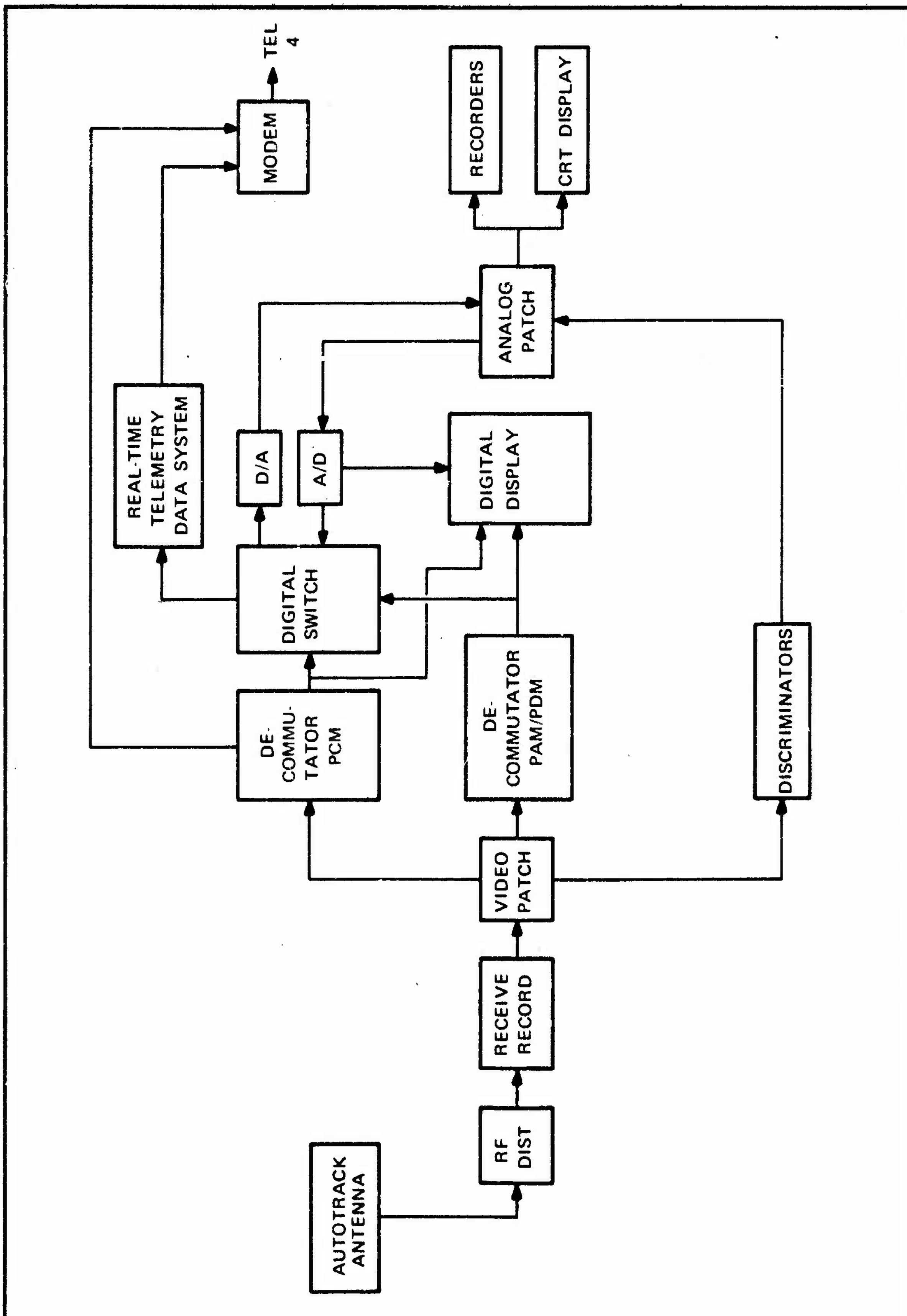


Figure 2-1. Typical Telemetry Site Abbreviated Block Diagram

On the ETR, these are nominally 2.4 kb/s on high frequency (hf) radio or satellite relay from Ascension Island, ships, and aircraft; 76.8 kb/s on the Grand Turk and Antigua to Cape undersea cable; and 384 kb/s on the Grand Bahama Island to Cape cable.

2.2.2 Telemetry Receiver/Recorder Group (TRKI-12)

The receiver/recorder group of the telemetry system (TRKI-12) is a complete electronic assembly designed to receive and record predetected and detected telemetry signals. The telemetry data receiver consists of three major chassis:

- Rf preselector/first converter
- Second i-f amplifier/demodulator
- Video amplifier

2.2.2.1 Receiver

The primary features and capabilities of the receiver are:

1. The receiver provides reception of frequency, phase, or amplitude modulated carriers and demodulation of fm, PDM (pulse duration modulation), PAM (pulse amplitude modulation), SSBAM (single sideband amplitude modulation), PM (phase modulation), and PSK (phase shift keying) information.

2. The receiver is a dual i-f channel, double-conversion, superheterodyne receiver capable of receiving rf frequencies in five discrete bands (selectable by five plug-in rf tuners):

   - 105 MHz to 140 MHz
   - 216 MHz to 260 MHz
   - 285 MHz to 410 MHz
   - 920 MHz to 965 MHz
   - 2200 MHz to 2300 MHz (except Grand Turk)

3. Bandwidths of both i-f demodulator channels are selectable by plug-in second i-f assemblies from 2.5 kHz to 6.0 kHz (one link per station except Grand Turk).

The receiver area equipment includes six identical racks (each containing two vhf/uhf receivers), a dual-channel spectrum display unit, a diversity combiner, a dual-channel predetection converter (used with up- or down-converter plug-in units), and a local receiver patch panel. For the support of this equipment, a dual-trace oscilloscope, an electronic counter, and an rms voltmeter are provided.

2.2.2.2 Recorder

The recorder area equipment includes one fm record/reproduce electronics assembly (with 6-channel record, 2-channel reproduce capacity and calibrating equipment), two 7/14-channel magnetic tape recorder/reproducers (AMR-FR-1400 or VR 3700B), two dual-channel predetection converters (used with up- or down-converter plug-in units), one 20-channel data insertion converter, one single-channel data insertion converter calibrator, two 8-channel direct write recorders, 20 distribution amplifiers, and one video/i-f distribution panel. For the support of this equipment, a frequency response generator, a dual-trace oscilloscope, an electronic counter, an rms voltmeter, a video spectrum display unit, a square wave generator, and a sine wave generator are provided.

Recording data characteristics are:

Recorder Speed (in/s)	Video Carrier (kHz)
120	800
120	900
60	450
30	225
15	112.5

Recorder Speed (in/s)	Predetection Freq Range to be Recorded (kHz)	Fm Record Data Bandwidth (kHz)
120	100 - 2,000	NA
120	300 - 2,000	dc-500
60	150 - 750	dc-250
30	75 - 375	dc-125
15	37.5 - 187.5	dc- 62.5

2.2.2.3 Telemetry Receivers/2-MHz Recorders

The receiver rack contains two dual-channel receivers, two combiners, and a dual-channel spectrum display unit. The receivers have replaced the existing receivers in some TRKI-12 systems. The

other capabilities of the system remain the same except for the systems which also have additional 1-in tape recorders. These systems have added a 20-channel data insertion converter and five video distribution amplifiers.

The telemetry receiver is contained in a single chassis with the capability of receiving polarization diversity signals. The receiver is a dual-conversion superheterodyne receiver employing a single first local oscillator and separate second local oscillators. The receiver provides reception of frequency or phase modulated signals with a 2-MHz detected bandwidth.

The receiver has the following front panel plug-ins:

Tuning unit . . . . 2200 - 2300 MHz
I-f amplifier/filters . . . 1, 2, 4, and 6 MHz
Demodulator . . . . . Frequency and phase modulation

The combiner is a dual-channel optimal ratio combiner which is agc controlled. The combiner is capable of simultaneous pre- and postdetection combining. Outputs are available to provide down-converted (900 kHz, 800 kHz, 600 kHz, 450 kHz, 225 kHz, and 112.5 kHz center frequencies) predetection signals from the two receiver inputs as well as the combined output. The predetection bandwidths are:

Center Frequency (kHz)	Bandwidth (kHz)
900	300 - 1,500
800	100 - 1,500
600	200 - 1,000
450	150 - 750.0
225	75 - 375.0
112.5	37.5 - 187.5

The 1-in tape recorder can record or play back 14 channels (10 direct, 4 fm) with a response of 2 MHz on direct. The following tabulates speed and frequency response:

Speed (in/s)	Frequency Response Direct	Frequency Mod.
120	400 - 2 MHz	dc - 500 kHz
60	400 - 1 MHz	dc - 250 kHz
30	400 - 500 kHz	dc - 125 kHz
15	400 - 250 kHz	dc - 62.5 kHz

2.2.3 Tape Playback Subsystem TDM-I

The TDM-I subsystem will play back tape recordings of predetected and postdetected data for the data separation station and tape copy subsystem that have been received and recorded by the predetection receiver/recorder group.

Translation and demodulation of the recorded predetection data is accomplished by the predetection playback and demodulation unit. Fm reproduce electronics is provided for playback of postdetected signals. These units consist of plug-ins which are identical to those in the receiver/recorder group (TRKI-12). The TDM-I subsystem has a data time-base expansion of 8:1 for predetection (i-f) and fm record data.

The major components are: two track recorder/reproducer AMR-FR1400, eight predetection playback and demodulation units, six fm reproduce channels, calibration, system monitoring, and distribution units.

2.2.4 Tape Copy Subsystem TMM-7

The TMM-7 subsystem provides the Range User multiple copies of all the primary telemetry data from the various stations. Up to three copies at a time of predetected or postdetected fm data can be recorded directly within the subsystem or four copies using the tape playback subsystem of the TRKI-12. The major components are: four 7/14-track magnetic tape recorder/reproducers, seven fm record electronics, two fm reproduce electronics, and calibration and distribution units.

2.2.5 Post-Detection Tape Copy Station (MPDL)

The Post-Detection Tape Copy Station is an integrated system capable of multiple magnetic tape copying of postdetection telemetry data. The system contains six Mincom M-32 intermediate band recorder/reproducers. Five copies from a master tape, two copies each from two master tapes, or six copies from an external source may be made simultaneously.

Control logic circuits provide for simultaneous operation of all recorders or for individually selected ones from a central control panel. Signal routing within the system is controlled at a central

patch panel to enable checkout and setup of individual components for various operations. Calibration, setup, and monitoring equipment, switchable between tape channels and between recorders, is included to monitor data quality, and is a permanent part of the station. These two include two subcarrier spectrum display units, a dual-trace oscilloscope, two broadband spectrum analyzers, a wave analyzer, and a bandswitching discriminator. Additional test and setup equipment contained in the station include an rms voltmeter, function generator, sweep generator, bulk tape degausser, and seven signal distribution amplifiers.

Each of the six recorder/reproducers contained in the system is a ½-in 7-track machine with seven channels of direct record/reproduce electronics. The recorders are classified as IRIG-compatible intermediate band machines.

Signal electronics characteristics are as follows:

Tape Speed (in/s)	Data Bandwidth (+3 dB)	Signal-to-Noise Ratio (dB)
120	370 Hz to 600 kHz	32
60	370 Hz to 300 kHz	30
30	350 Hz to 150 kHz	30
15	300 Hz to 75 kHz	30
7.5	200 Hz to 37.5 kHz	25
3.5	200 Hz to 17.17 kHz	25

2.2.6 TDM Decommutators Types I and II

The TDM (time division multiplex) decommutators accept serial data trains with most commonly used modulation schemes. Both types of TDM's can uniquely identify up to 799 words, of 3 to 13 bits per word per frame and subframe. The TDM's can be set up manually by front panel controls and switches or by punched paper tape.

The TDM I and II have the following subsystems: primary synchronizer, PCM secondary synchronizer, and core memory decommutator. The TDM I also contains a PAM/PDM converter.

The primary synchronizer accepts PCM signals of non-return-to-zero (NRZ) -L (level), M (mark) and S (space); RZ; and bi-phase L, M, and S. The incoming bit rates for NRZ codes are from 1 to 500,000 b/s.

The PCM secondary synchronizer establishes word, frame, and subframe synchronizations. Word synchronization is established using search, verify, and lock logic circuitry. The word-sync recognizers of one to three bits are provided. Frame synchronization is performed by pattern recognizers which can be used for complementary frame synchronized patterns.

Subframe synchronization can be programmed in up to six subframe patterns of 3 to 64 bits each, using search, verify, and lock for each pattern.

The PAM-PDM converter accepts various incoming signals as follows:

Signal	Duty Cycle	Rates
PAM-RZ	30 to 90%	20,000 b/s
PAM-NRZ	100%	40,000 b/s
PDM	Per IRIG 106-73	

The capacity of the TDM I and TDM II is 799 channels in the main frame and 799 channels in the subframe. PAM synchronization can be obtained for two or three channels frame synchronization coding as described in IRIG 106-73. PAM sync can be maintained with as many as 10 pulses missing from the incoming data stream.

The core memory decommutator provides a flexible way to decommutate commutated, supercommutated, and subcommutated channels in both main and subframes.

The TDM II contains two primary synchronizers and two main frame recognizers. These provide two independent synchronizers for bit, word, and frame synchronizers and two main frame recognizers.

Each decommutator contains a bandswitching discriminator module capable of handling all IRIG frequencies (proportional bandwidth). A tape speed compensation system is included in each decommutator.

The TDM II also has provisions for an automatic switchover. Predetermined data rate changes or coded control words within the transmitted data formats can be used to make the switchover.

2.2.7 TDM Decommutator Type III

The TDM III is a relatively simple and low cost PAM/PDM decommutator which translates standard IRIG PAM/PDM signals into the ETR common language format. System characteristics are similar to the TDM I in the PAM/PDM modes except that the TDM III's cannot handle PAM subcommutation.

2.2.8 Fixed Discriminator System, Model 210

The Fixed Discriminator System consists of a relay rack containing six rack adapters and all necessary jack panels for test and signal distribution. Each rack adapter can accept six Model 210 plug-in discriminators with 18 units presently installed in each system. The Model 210 discriminator accepts plug-ins for channel selection and output filter characteristics. The major design specifications for the Model 210 discriminators are as follows:

1. Center frequency and deviation; determined by channel selector plug-in; available for all IRIG bands as detailed in IRIG Document 106-73. Constant bandwidth or other special channel characteristics can be accommodated by special plug-ins.

2. 60 dB of dynamic input range.

3. Low-pass output filters with constant amplitude or constant delay characteristics available to match channel characteristics.

2.2.9 Tunable Frequency Discriminator System

The Model 229 tunable frequency discriminator consists of a fixed frequency discriminator and a special tuning unit. The design specifications are as follows:

1. Tuning range: Accepts any subcarrier channel with a center frequency from 300 Hz to 300 kHz.

2. Subcarrier frequency deviation: ±7½%, ±15% switch selectable.

3. Deviation ratio: 1, 5, 10, 25, 50, and 100; switch selectable.

4. Data frequencies: 3 Hz to 30 kHz selectable by dial and switch.

5. Linearity is ±0.1% of bandwidth for ±7.5% deviations and ±0.2% of bandwidth for ±15% deviations.

6. Output noise: The rms value of output noise is less than 0.2% of full-bandwidth voltage.

7. Output voltage is single ended and referenced to ground. The deviation sensitivity is negative. Gain can be controlled between ±1 volt and ±10 volts.

8. Output filter response: Switch selectable for constant phase or constant amplitude 18-dB rolloff.

2.2.10 Analog-to-Digital Converter, Model 2239

The Model 2239 analog-to-digital converter accepts, normalizes, and multiplexes up to 48 bipolar analog input signals. The output is a parallel digital 10-bit word per sampled analog data. Each data word is transmitted with a 5-μs clock pulse and a binary-coded decimal (BCD) 7-bit channel address (common language format) for use by the computer formatter, and real-time telemetry data system.

It has the following design features:

1. Accepts and normalizes the individual analog inputs having full scale values ranging from ±1 volt to ±20 volts.

2. Selects data channels for multiplexing sequentially or in random fashion by means of a program patchboard with a sampling rate up to 20,000 words per second.

3. Samples and holds each analog signal and converts it to a 10-bit parallel word in less than 3 μs.

4. Transmits each parallel data word with clock and BCD channel address in common language format at 20,000 words per second or less.

2.2.11 Digital-to-Analog Converter, Model 2119 and 2120

The digital-to-analog conversion system accepts up to five separate digital common language inputs for conversion to analog form for recording and display. Each digital input source may be connected to one Model 110 digital-to-analog converter group consisting of 10 each address selectors, word structure programmers, digital-to-analog converters, and analog output lines. The five Model 110 D/A groups per system provide 50 analog outputs. The Model 2119 has internal test capabilities. The Model 2120 uses an external Model 2123 test analyzer. Differing only in self-test facilities, each of these systems has the following design features:

1. Accepts a parallel digital data word accompanied by clock and channel address (ETR Common Language).
2. Selects the data word by means of front-panel thumbwheel switches which are set by the operator to the desired 3-digit channel address and, if required, 3-digit subchannel address.
3. Selects up to nine bits from the incoming 12-bit common language data word by means of a word structure patchboard.
4. Converts the 9-bit word to analog form for output on one of 10 analog output channels per D/A group.

2.2.12 Data Processing (Computer Formatter)

The Computer Formatter accepts common language input data with time and stores this information on magnetic tape in a computer compatible format. It can edit channels, delete out-of-sync data, and flag data. The system operates in two modes: all data and patch program.

2.2.12.1 All Data Selection

In the "all data" select mode, all incoming data is formatted onto a computer tape. Three methods of frame synchronization are provided, selectable at the option of the operator:

1. Channel-Subchannel Synchronization: Frame synchronization upon the coincident appearance of a designated channel and a designated subchannel, each independently selectable by thumbwheel switches from 799 channels and 799 subchannels.
2. Frame Recycle Pulse Synchronization: Frame synchronization controlled by the detection of the frame recycle pulse generated by the TDM station.
3. Combined Synchronization: Frame synchronization upon coincident appearance of both the frame recycle pulse and the selected channel MFID/SFID.

2.2.12.2 Patch Program Selection

The data selection program in the patch program mode can select any combination of 512 channels or subchannels for incorporation onto a computer tape. The patch program is incorporated in the patch panel. Provisions have been made for patching the memory load control so that the data can be packed into the 36 bits, however the programmer desires. Any one or any combination of formats and groups can be used. Synchronization is patchable in this mode. Any subframe ID or any channel ID can be used as a start signal. Either Program Continue or Data Delete can be selected. If Program Continue is selected, the computer formatter buffer will format all programmed data and truncate when the TDM reacquires from an out-of-sync condition. Data Delete will delete all the out-of-sync data and only terminate when programmed.

The Frame Channel Separator and Memory System provides efficient computer record length. The memory can:

1. Accept different data rates, inter-mixed word lengths or groups, and frame lengths as inputs.
2. Combine the data with time identification.
3. Arrange all the data channels in any desired position in the computer format.

The Frame Channel Separator has a random frame selection capability from the major cycle start identification of one to 10 frames containing known subchannels. The separator also can select every frame, second frame, fourth frame, eighth frame, or 16th frame for computer processing.

The multiple frame formatted per tape record provides a continuous recording of two or more frames of formatted data before a record gap. The number of frames formatted can be selected by thumbwheel switches:

FRAME SYNC RECOGNITION
WORD SYNC RECOGNITION
SUB-FRAME SYNC RECOGNITION
WORD PER FRAME RESTART

2.2.12.3 Computer Format Converter

The computer format converter provides a compatible selected-format for the computer tapes. The converter can program data entry tapes at 200 and 556 bits/inch packing densities. The parity check is patchable to provide for all modes. The parity check and the parity bit insertion is included for both lateral and longitudinal positions on the tape. A parity check is made on the output tape during preparation of the recording.

The tape format generation for computer entry includes all requirements for the maximum efficiency in computer entry including tape gaps, stop marks, and/or file marks and data control marks.

The system can format nine 36-bit computer words of different data word composition and two 36-bit computer words of different time word composition. Variable input words from 4 to 64 bits can be integrated into the nine computer words.

2.2.12.4 IBM Format Recorders

Two magnetic tape recorders, ½-in 7-track, are provided for recording IBM format tapes. The recorders provide packing densities of 200 and 556 bits/inch. The recording speeds and the recorder stop and start times are chosen for maximum time efficiency and continuous operation in the production of a computer tape. The recorders operate in five modes:

Continuous recording
Parallel recording
Tape copying
Single recorder operation
Overlap recording

The recorders operate alternately to provide continuous recording of data. All required command signals are provided for this operation. A selectable number of overlap records is available. In the tape copying mode, the data on one tape is copied onto the second tape of the formatter.

2.2.13 Range Time Decoder

The range time decoder provides time words for correlation of the data on the computer tape to within 1 ms. In addition, the decoder may be used for time search of the input tape and visual time display. The decoder supplies decimal readout in days, hours, minutes, seconds, and milliseconds from the 100/1,000 p/s range time code generator. A time control delays the seconds time changeover from ±50 ms to 1-ms increments.

The decoded range time is recorded on the computer tape, in one or more computer words, in any position in the record. The decoded range time is recorded at a recurrent rate to provide accurate time correlation of the data on the computer tape to within 1 ms for forward and reverse time. The time readout can be correlated with any word in the data record recorded on the computer tape.

The time decoder provides a new decoded time word at the detection of the leading edge of the range time markers.

2.2.13.1 Tape Start and Stop Time Selection Controls

The Selection Control is provided for the preselection of recording time interval referenced to recorded range time for the processing of a computer tape. The time selection switches for determining the recording time interval are compatible with the time display. Six sets of switches are provided for selecting the automatic starting time of the recording interval for both forward and reverse time recording. An end-of-file is provided after each time period selected.

2.2.13.2 Identification Control

Two methods are provided to enter identification data onto the computer tape. The first is a series of

thumbwheel switches arranged in groups as follows: identifying data - 6 characters, run number - 4 characters, reel number - 2 characters, recording location - 2 characters, primary recording device - 2 characters, secondary recording device - 2 characters, and special identification - 6 characters. The second method is a paper tape entry in which all of the above identification data plus complete identification can be provided. ID entry on tape does not preclude the recording of data records only.

2.2.13.3 Computer Tape Time Placement

The time word reference for the computer tape can be integrated into the computer tape format in any desired position to provide complete time correlation of the data with all possible conditions of frame stripping.

2.2.13.4 Additional Capability

The range unit addition to the ETR Range Time provides the capability of handling IRIG 104-70 formats A and B. The BCD format is used.

2.2.13.5 Range Time Input

Patch facilities are provided for receiving various time codes from four input lines. The range time input impedance is 10,000 ohms. The input voltage is 5 volts peak-to-peak.

2.2.14 Data Corrector System

The Data Corrector System performs real-time operations on telemetry data. Depending upon the particular program (software) used, either on-line or off-line digital operations may be performed by the data corrector. Primary on-line operations consist of receiving real-time telemetry data (common language format), editing and correcting this data, and producing outputs for the display and mission control. Data and other information may also be recorded on magnetic tape for postmission analysis. Off line, the data corrector may be used to perform many general purpose computer functions: assemble and check out its own programs, generate programs for other stored program telemetry equipment such as the TDM I and TDM II, check and dump computer formatter tapes, etc.

Communications with other telemetry equipment is carried out in real-time through its common language (CL) interface. The heart of the Data Corrector System is a small-scale solid-state general purpose digital computer (Beckman Model 420) having an 18-bit word length and a memory capacity of 16,384 words. There are two standard input/output channels and a third high-speed input channel (DME) which use the direct memory access feature of the computer. Peripheral devices include a card reader, a line printer, a high speed code converter, and a magnetic tape unit.

2.2.15 Oscillographic Recorders

The primary oscillographic recorders used on the Range are Honeywell 1612's. These machines make permanent recordings for distribution to the Range User. They have the following specifications:

1. Provide 17 data and a timing channel on one paper strip.
2. Have frequency response from dc to 5 kHz (with special high frequency galvanometers: dc to 13 kHz).
3. Provide 15 chart speeds from 0.1 in/s to 160 in/s.
4. Provide quick identification of traces by interruption of galvanometer light beams.

2.2.16 Pen Recorders

The Brush Mk 200 recorders on the Range have essentially the same configuration. The design details are as follows:

1. Provide eight channels of low frequency data recording plus timing.
2. Provide separate timing inputs to be displayed on right side, left side, or both sides through separate marker amplifiers.
3. Provide chart speeds from 0.002 in/s to 8 in/s in 12 steps.
4. Provide provisions to remotely control the recorder if required.
5. Provide an internally generated 0.1% reference voltage to the 25 pens for calibration.

6. Handle data amplitudes from ±1 volt to ±20 volts.

2.2.17 Digital Bar-Graph, Model 2321

The digital bar-graph display provides an analog display of up to 40 channels stripped from the common language signal. The design features are as follows:

1. Converts variable-length digital data to a form suitable for bar-graph display.
2. Accepts telemetry data and channel addresses in ETR common language for word rates to 100 kHz from one of eight switch-selected sources.
3. Selects channels to be displayed by thumbwheel switch indicating channel and subchannel.
4. Normalizes inputs to provide full scale bar heights regardless of input word length.
5. Adjusts frame length to display either 10, 20, 30, or 40 channels starting from either channel 1, 11, 21, or 31.

2.2.18 Digital Display

The digital display unit accepts common language inputs and distributes the data to such displays as 7-digit Nixies, analog meters, event meters, multistylus event recorders, and digital printers. The Nixies and analog meters display transient signals, and the event recorders and printers provide a permanent record of data.

A programming selector (patchboard) will select the channels to be displayed or recorded. A digital printer prints binary or binary-coded decimal. A multistylus recorder provides an alternate means for displaying binary data. Alphanumeric readout devices have lamp visual displays for decimal digital data. Special alarm meters, with adjustable tolerance, monitor digital data.

2.2.18.1 Multistylus Event Recorder

A self-contained 150-channel event recording instrument manufactured by Brush Instruments. The recording units accept on-off type data signals which are recorded on permanent chart paper. One channel is used as a timing channel for accurate event timing information. The technical characteristics are:

Number of styli:	150
Response:	Up to 1.25 ms at maximum chart speed.
Chart speeds:	5, 10, 20, 50, 100, and 200 mm/s and 0.05, 0.1, 0.2, 0.5, 1 and 2 mm/s.

2.2.18.2 Digital Printer

This printer is a Hewlett-Packard 526-A with 11 columns utilizing standard code wheels. The display unit includes a binary-to-BCD converter to print either octal or decimal.

2.2.18.3 Nixie Readouts

Ten banks of 7-digit in-line displays which are single channel selectable.

2.2.18.4 Analog Meter

Ten meters with 10-volt full scale range. Separate DAC units with 9-bit binary resolution are included. Separate dividers for external inputs of 30 volts are included (the included DAC's provide levels to 10 volts maximum, unipolar). Adjustable alarm limits (both high and low) on each meter energize a latching error indicator. The error light acts on an input below low limit (only), above high limit (only), or out of either limit.

2.2.19 Real-Time Telemetry Data System

The Real-Time Telemetry Data System (RTTDS) was developed so that remotely and locally acquired telemetry data could be delivered to users in real-time. To accomplish this, the RTTDS performs the following major functions:

1. Selects data from multiple asynchronous telemetry down links.
2. Formats the mixed data channels for uprange retransmission.
3. Decommutates the received downrange data mix at the central telemetry facility.

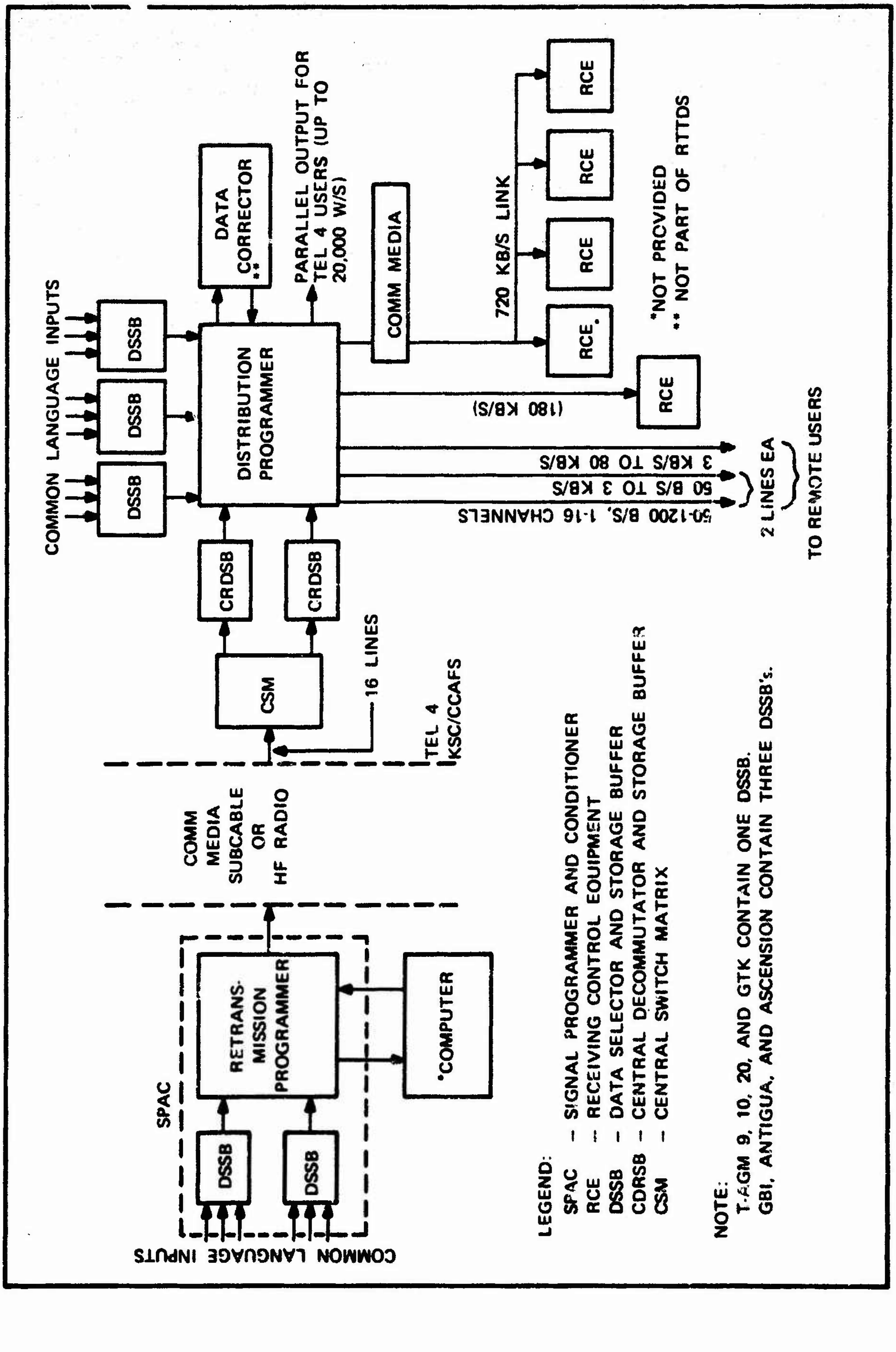


Figure 2-2. Real-Time Telemetry Data System Block Diagram

4. Selects locally acquired data to combine with remote site data.

5. Provides several output data formats at various word rates and channel groupings for transmission to various users.

A simplified block diagram of the system, depicting the flow of data, is shown in figure 2-2. The data inputs to the system are from multiple digital common-language (CL) sources consisting typically of TDM Type I, II, and III decommutators and A/D conversion systems. A remote site subsystem is called a signal programmer and conditioner (SPAC). Each SPAC consists of two major types of equipment: a data selector and storage buffer (DSSB) and a retransmission programmer (RP). The number of DSSB's per each SPAC can vary from one to six. Figure 2-2 identifies the number of DSSB's installed with each SPAC. A DSSB has three CL inputs and can simultaneously accept and store data in memory, in parallel form, at asynchronous input rates up to a combined total of 100,000 w/s. In addition, it can select and store a time word with each data word selected. Data word length can be from 4 to 12 bits per word.

A DSSB contains a 4098-word by 26-bit magnetic core memory where program instructions and data are stored. The RP, which is more complex than a DSSB, selects data from each DSSB memory, the programmable patch panel, and a computer and merges this data into one output serial bit stream, the format of which is under program control. The output bit rate capability is from 25 b/s up to 400 kb/s. The output serial bit stream is routed into communications interface equipment (modem) where it is converted into a form suitable for transmission over a submarine cable or high frequency radio, whichever is applicable. The maximum bit rates from the downrange sites are: Grand Bahama - 384 kb/s; Antigua and Grand Turk - 76.8 kb/s; all others - 2.4 kb/s. The RP can handle words of mixed length (4 to 12 bits). It also has truncation capability for words over four bits long. The RP magnetic core memory system holds 4,096 words of 30 bits each and contains the program instructions.

The SPAC contains a program entry and control (PEC) panel which provides manual access to the RP and DSSB memories. Programs can be manually read into any of the memories and the contents of any memory location can be read out and displayed on the PEC panel. Programs are normally entered in the memories via paper tape from a tape reader which is part of the PEC. The DSSB's and RP can store two programs and change from one to the other by merely actuating a switch. Also new programs can be read into the system while it is operating without interference to the operating program.

The Central Site equipment consists of a central switch matrix (CSM), two central retransmission decommutator and storage buffers (CRDSB), a distribution programmer (DP), a central control console (CCC), and three DSSB's. Receiving control equipment (RCE) is located at users' interfaces at KSC and CCAFS.

The serial bit streams from downrange are routed to the CRDSB's via the CSM. The CRDSB's, under program control, decommutate the data and store it in known locations in their 4096-word by 32-bit magnetic core memories. The maximum serial input rate to a CRDSB is 200 kb/s. The DP, under program control, selects data from the DSSB's and the CRDSB's and combines this data into one or more of several output formats and rates described below:

1. A high rate parallel output (up to 20,000 w/s) for display within Tel 4.

2. A high rate serial output (up to 720 kb/s) with either BCD or binary ID's for users at KSC and CCAFS. This link contains the same data as 1 above.

3. A serial output link to the Real-Time Computer System with a maximum rate of 180 kb/s. RCE's are provided to the users of this output and 2 above. The RCE is essentially a serial-to-parallel converter.

4. A serial output which can be interfaced with a Bell 301-B or similar modem. The rate is variable from 3 kb/s to 80 kb/s with a fixed stop at 40.8 kb/s. This link is for transmitting data to remote user locations.

5. Two serial output links (their data content can be different) for remote users as in 4 above. The rates are from [illegible] b/s to 3 kb/s. These links can be

interfaced with Bell 201 or similar modems.

6. Two TTY links for providing data to remote users as in 4 above. These are 50 to 1200-b/s links (depending on format and number of channels) and each may contain different data words.

The 2400 b/s maximum retransmission capability from sites and ships connected to CCAFS via hf radio is provided by the hf data modems described in paragraph 3.1.1.2. The retransmission capability from the subcable sites is provided by modulators and demodulators. These modem systems can transmit up to 76.8 kb/s over a 48-kHz bandwidth communications circuit and up to 384 kb/s over a 240-kHz circuit. In addition to handling data from a SPAC to the RTTDS Central Site and from the Central Site to a user at KSC or CCAFS, these modems can be used to retransmit serial bit stream data after it is regenerated by a TDM primary synchronizer at the downrange station. Modulators are currently located at Grand Bahama, Grand Turk, and Antigua; demodulators are located at Tel 4/KSC and at the Real-Time Computer System.

2.2.20 USNS Redstone Telemetry

The Redstone telemetry system includes subsystems necessary for the acquisition, detection, and tracking of telemetry signals; reception and recording of these signals; separation and demodulation of fm subcarriers; decommutation of PAM, PDM, and PCM signals; and display of selected data in real-time and/or processing for retransmission to remote locations.

2.2.20.1 Antenna Subsystem

The antenna subsystem consists of four independent automatic tracking telemetry antennas, which cover the 2200 to 2300-MHz band, complete with individual acquisition aid antennas. The main antenna has a gain of 38 dB and a system noise temperature of 280 K. Each antenna has azimuth travel limits of 750° and elevation travel limits of -11° to 105°. The antenna is capable of tracking rates of 40°/s and acceleration rates of 30°/s² in both axes. The above rates for elevation apply only between zero and 90° with rate limiting applied beyond these limits. Included with each antenna are two preamplifiers (right and left circular polarization), two down-converters, multicouplers, auxiliary test equipment, and two dual-channel tracking receivers with both narrow and wideband tracking modes. The down-converters convert the 2200 to 2300-MHz frequencies to the 300 to 400-MHz frequency range. The antennas are locally stabilized by coordinate converter packages using ship's attitude inputs from the Ship's Position and Attitude Measurement System (SPAMS).

The antenna subsystem, via digital encoders, provides the Central Data Processing System (CDPS) with elevation and azimuth antenna position data. The CDPS contains a telemetry buffer which interfaces the antennas with the UNIVAC 1230 computer. Each antenna accepts digital designate data from the computer, by way of the telemetry data buffer, independent of the other antennas. Each antenna can operate in the following modes: standby, manual, autotrack, forced track, and computer designate. In addition, each antenna can be operated in the manual mode with internally generated analog scans and in the computer designate mode with computer generated digital scans.

The Central Data Processing System provides pointing angles for the antenna subsystem. The pointing angles are derived by the computer from launch platform position data from the LASS and from DRSS position data from SPAMS.

2.2.20.2 Receiver Subsystem

The receiver subsystem consists of two receiver portions of two TRKI-12 receive/record stations. It consists primarily of 24 receivers, 12 diversity combiners, 12 predetection down-converters, 14 local patch panels, 2 video i-f patching cabinets, and 2 test equipment cabinets.

2.2.20.3 Recording Subsystem

The recording subsystem consists of five 14-track magnetic tape recorders. This system consists of fm record electronics, recorder test equipment, data insertion converters, predetection up-converter, and predetection playback monitors from the recording subsystem of two TRKI-12 systems.

2.2.20.4 Data Separation and Decommutation Subsystem

The data separation and decommutation subsystem consists primarily of TDM-I, one TDM-IA, a digital

bar-graph, 12 fixed frequency discriminators, 18 tunable discriminators, four oscillographs, seven pen recorders, one data insertion converter, A/D converters, D/A converters, a signal programmer and conditioner (SPAC), and associated test equipment.

In the data separation and documentation subsystem, standard IRIG, PAM, PCM, and PDM commutated data are decommutated by the TDM-I and IA. Outputs from this subsystem are patched to the pen recorders.

2.2.20.5 Signal Programmer and Conditioner (SPAC)

Data to be retransmitted in real or near-real time are processed through the SPAC after demultiplexing in the TDM-IA. This system conditions and reformats the data into parallel data streams for retransmission over the high-speed hf data link to remote stations. Data modems and retransmission facilities are part of the communications system. Data may be shifted out of the SPAC at rates up to 2400 b/s. Telemetry data recorded in video form on magnetic tape recorders may be retransmitted to aircraft or close-range bases through a vhf retransmission system.

2.2.21 ARIS Telemetry

The ARIS telemetry subsystem serves a dual purpose: (1) as an automatic tracker it provides angular data that can be put on the master designate bus to assist the radars in acquiring a target, and (2) as a data collecting and recording system it provides telemetry data in the standard telemetry bands within the frequency range of 216 to 2800 MHz. The ARIS also carry special telemetry equipment to collect data within the 60 to 4000-MHz band.

The telemetry tracking antenna employs a dual-element log periodic broadband feed system for frequencies from 215-2800 MHz (19 dB-38 dB gain, respectively). One element receives right circular polarized (RCP) signals and the other receives left circular polarization (LCP). The conical scan rate of 600 r/min produces a 10-Hz error signal for autotrack. The system can track on either RCP, LCP, or in a combined mode, using a 30-ft parabolic dish mounted on an antenna mount identical to the radar mounts. The antenna mount can be slaved to the designate bus controlled by the master selected in the Operations Control Center (OCC), or can control this bus, if selected as master.

The TRKI-12 system is used for receiving and recording telemetry data. The TRKI-12 system consists of 12 telemetry data receivers, six spectrum display units, six diversity combiners, six predetection converters, two predetection playback monitors, two FR-1400 magnetic tape recorders, two direct-write recorders, one data insertion converter, one fm record/reproduce electronic unit, and necessary test equipment and patching facilities.

Each telemetry data receiver provides reception of fm, pm, and a-m carriers and demodulation of fm, PDM, PAM, PCM, PACM, and pm. Separation and display equipment consists of a Time Division Multiplex Type II (TDM-II) station and TDM-II test unit, fm fixed discriminators, tunable discriminators, D/A converters, A/D converters, digital bar-graph display, oscillographic recorders, and direct-write recorders.

The TDM-II derives primary and secondary synchronization from video signals for the reconstruction of the various modulated carriers using the basic PCM technique. The system will decommutate PCM at rates up to 1,000,000 b/s. A PAM/PDM to PCM converter in the system converts a PAM or PDM wavetrain to PCM for decommutation of this type data.

The 18 fm fixed discriminators are Data Control System Model GFD-2 subcarrier discriminators with the necessary plug-ins for the discrimination of IRIG channels 1-18 and A-E. The five fm tunable discriminators are EMR Model 229 units that can be tuned to any desired frequency between 300 Hz and 300 kHz; frequency deviation of ±7.5% or ±15% can be selected. A Monitor Systems Model 2119 D/A converter (50 channels) converts parallel digital outputs from the TDM-II to analog form for recording and display, and a Monitor Systems Model 2239 A/D converter (48 channels) digitizes discriminator outputs for remote transmission and computer use.

A Monitor Systems Model 2321 digital bar-graph (40 channels) converts parallel digital outputs from the TDM-II and displays up to 40 channels of digital telemetry data in the form of vertical bars, each representing a data word. Four Minneapolis

Honeywell Model 1612 recorders (18 channels each) are used for recording up to 54 channels of analog data at rates up to 5 kHz. Four Brush Instrument Mark 200 recorders (8 channels each) are used for recording up to 32 total channels of analog data at rates up to 58 Hz.

The Real-Time Retransmission System consists of a SPAC, a part of the Real-Time Telemetry Data System, and the High Speed Data Modem. The SPAC accepts up to three links of telemetry data from units such as the TDM-II and A/D converter for storage and selection, or selected data from the 1206 computer for retransmission in near real-time at a rate up to 2400 b/s. (This rate is determined by the High Speed Data Modem and the hf link since the SPAC can accept up to 100,000 data words per second.)

A special telemetry system enables frequency coverage over a range from 60 MHz to 4,000 MHz. The system consists of: (1) super high frequency (shf) autotrack system, (2) reentry vehicle (RV) receiving antenna system, (3) ground-look antenna system, (4) control console, and (5) magnetic tape recorder system.

A 40-in shf autotrack antenna dish is mounted on top of the 30-ft telemetry antenna. The traveling wave tube (TWT) preamp, filter, and 20-dB coupler are in a weathertight enclosure which is also on top of the 30-ft dish. The R-35 receiver is mounted in the rf enclosure on the back of the 30-ft dish. Although the receiver can tune from 2 to 4 GHz, the system will operate only between 2.665 GHz and 2.955 GHz because of the bandpass filter in front of the preamp.

The RV receiving antenna system consists of five antennas (including the primary 30-ft telemetry dish), six preamplifiers, five postamplifiers, and 12 receivers. The 5-antenna complex covers the frequency band of 60 MHz to 4 GHz. The six preamplifiers cover the same frequency band in five overlapping steps. The postamplifiers provide frequency coverage from 90 MHz to 4 GHz in five overlapping steps. The receivers cover the 60 MHz to 4 GHz band in four steps with a minimum of

TABLE 2-13. AFETR TELEMETRY FREQUENCY COVERAGE BY STATION

Frequency Range (MHz)	Location									
	Launch Area	Mobile TLM Van	GBI	GTK	ANT	ASC	PRE	Redstone	ARIS (2)	ARIA (8)
130-140	X		X		X		X**		X	X
225-260	X		X		X		X		X	X
285-315	X				X		X		X	
370-410	X		X		X		X		X	X(400)
920-965	X		X		X		X		X	
2200-2300	X	X	X	X	X	X	X	X	X	X
70-4000									X*	
1435-1535	X	X								

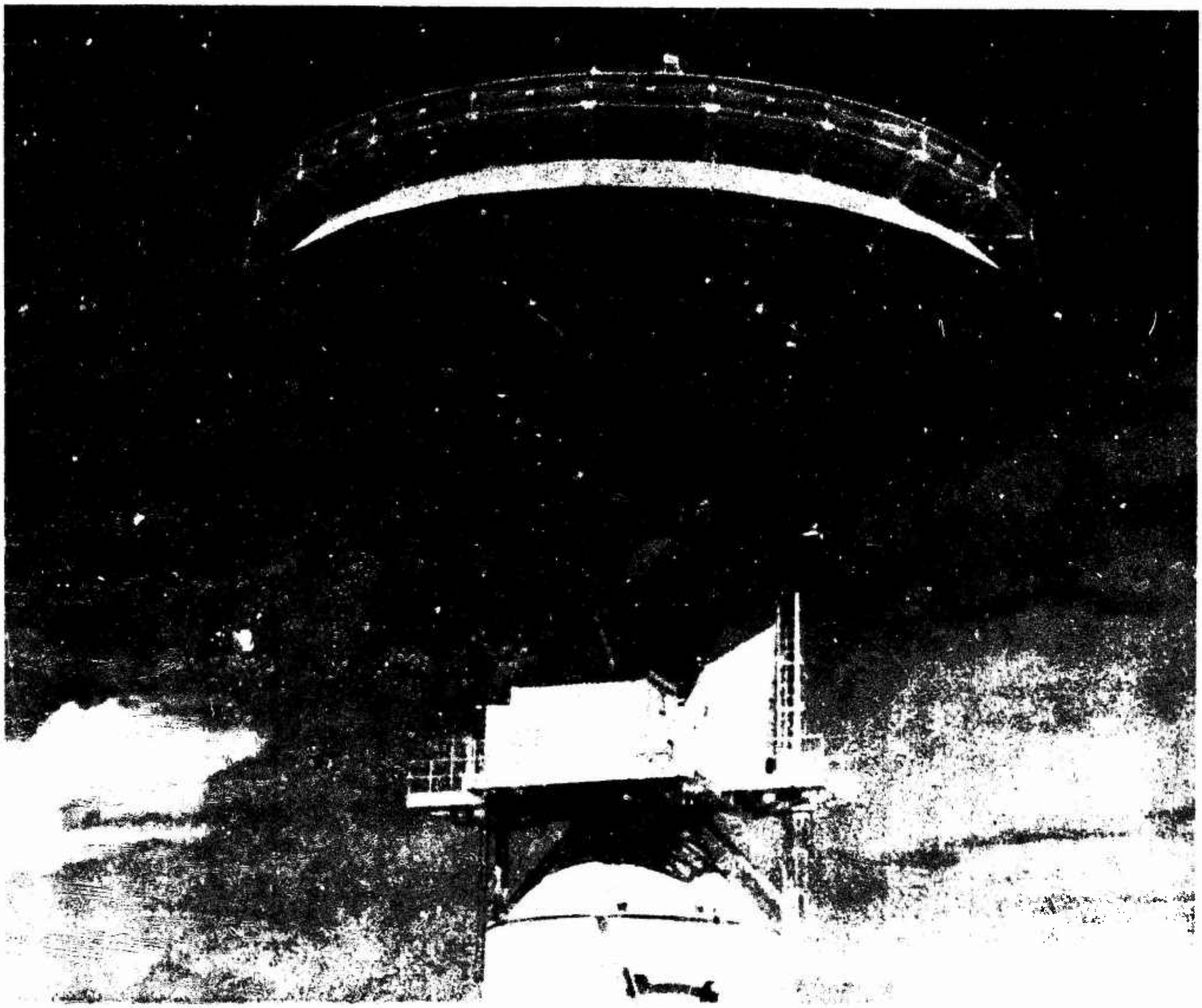
*Special capability for ARIS only.
**Pretoria, S.A., station is inactive.

two receivers for each step. In addition, the system contains the necessary multiplexers, multicouplers, demodulators, and converters for video and predetection display and recording.

The ground-look antenna system consists of two separate systems, one mounted on the portside of the ship and the other mounted on the starboard side. They are individually controlled from the control console. The combined system consists of four antennas, five preamplifiers, and eight receivers. The antennas cover the band of 60 MHz to 4 GHz in two steps. The preamplifiers cover this band in five overlapping steps, while the receivers cover the band in three overlapping steps. There is a minimum of one receiver for each band, and the system contains the necessary multiplexers, multicouplers, demodulators, and converters for video and predetection display and recording.

The control console contains the necessary test, control and display equipment for operating the special telemetry system. In addition, it houses the receivers and postamplifiers that are a part of the RV and ground-look antenna systems.

The tape recorder system consists of four CEC, VR-3600 1-in tape recorders with 14 tracks each, and two CEC, VR-3600 ½-in recorders with seven tracks each. Recording capabilities are from 400 Hz to 1.5 MHz on all tracks for either video or predetection recording.



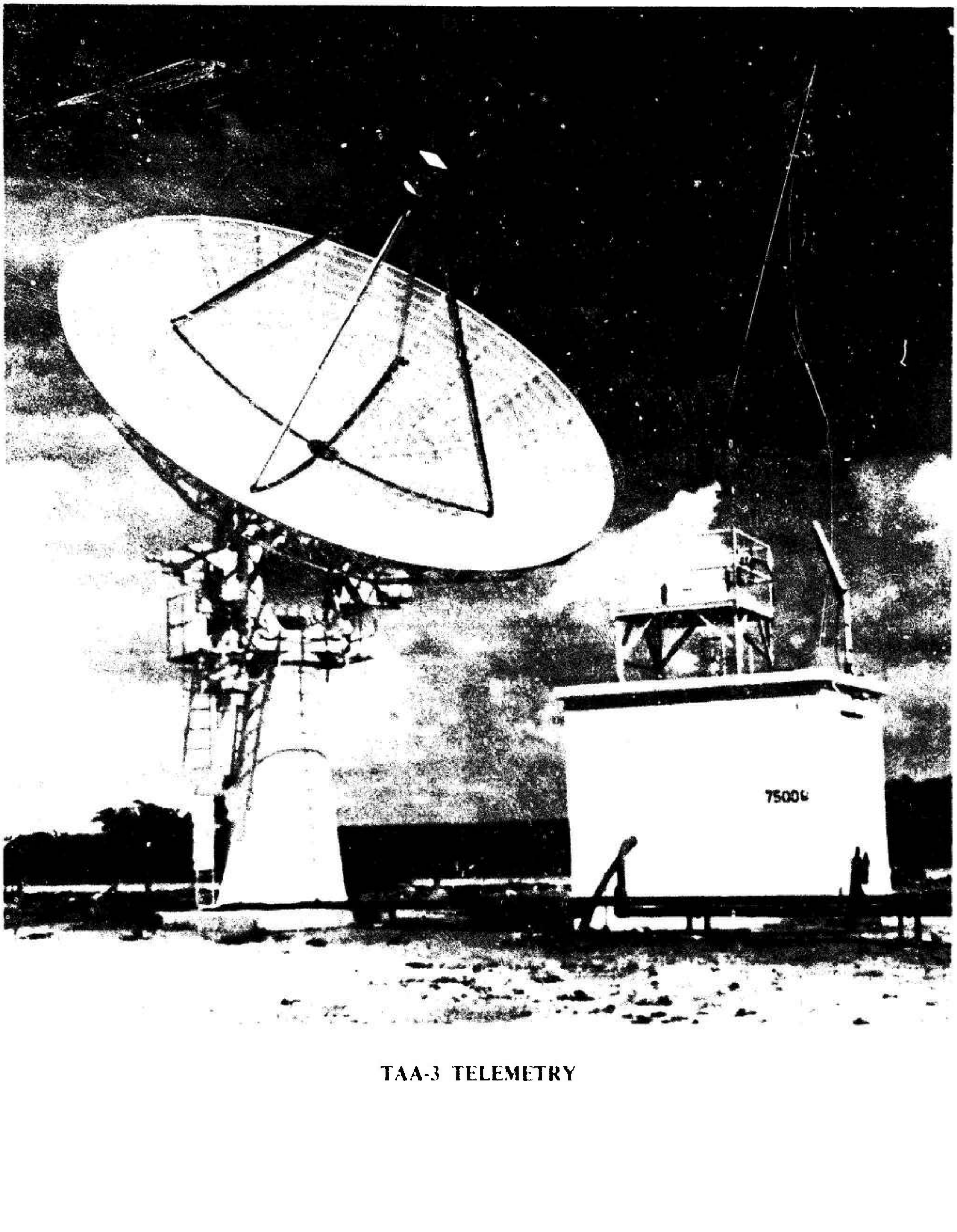
TAA-8/8A TELEMETRY

TABLE 2-14
TAA-8/GRAND TURK TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	Paraboloid (modified)
Size	80-ft diameter
Feed	Monopulse Cassegrainian (converted to pseudo conscan)
Scan rate (effective)	97 Hz
Pedestal	Elevation over azimuth
Pointing error	0.1° rms max. at velocities up to 5°/s and accelerations up to 3°/s/s
Tracking velocity	10°/s max. (both axes)
Tracking acceleration	5°/s/s max. (both axes)
Polarization	Right and left circular (simultaneous and selectable)
Frequency band	200-2300 MHz (down-converted to 300 to 400 MHz)
Antenna gain (reference at preamp input and like polarization)	51 dB (nominal)
Antenna beamwidth	0.34° (nominal)
Receiving system noise figure (reference at preamp input)	1.5 dB (nominal)
System noise temperature (antenna plus receiving system referenced at preamp input)	180 K (nominal)
System sensitivity; S = N (based on receiver i-f bandwidth of 500 kHz)	-119 dBm (nominal)

TABLE 2-15
TAA-8A/ANTIGUA TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	Paraboloid (modified)
Size	80-ft diameter
Feed	Monopulse Cassegrainian (converted to pseudo conscan)
Scan rate (effective)	97 Hz
Pedestal	Elevation over azimuth
Pointing error	0.1° rms max. at velocities up to 5°/s and accelerations up to 3°/s/s
Tracking velocity	10°/s max. (both axes)
Tracking acceleration	5°/s/s max. (both axes)
Polarization	Right and left circular (simultaneous and selectable)
Frequency band	2200-2300 MHz (also down-converted outputs available at 300 to 400 MHz)
Antenna gain (reference at preamp input and like polarization)	51 dB (nominal)
Antenna beamwidth	0.34° (nominal)
Receiving system noise figure (reference at preamp input)	1.5 dB (nominal)
System noise temperature (antenna plus receiving system referenced at preamp input)	180 K (nominal)
System sensitivity; S = N (based on receiver i-f bandwidth of 500 kHz)	-119 dBM (nominal)



TAA-3 TELEMETRY

TABLE 2-16
TAA-3/ASCENSION TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	Paraboloid	
Size	30-ft diameter	
Feed	Apex, offset circular cavity, conical scan	
Scan rate	10 Hz	
Pedestal	Elevation over azimuth	
Pointing error	±0.1° static plus ±0.05° per deg/s cumulative	
Tracking velocity	15°/s max. (both axes)	
Tracking acceleration	7°/s/s max. (both axes)	
Polarization	Right and left circular (simultaneous and selectable)	
Frequency band (MHz)	*2200-2300	**785 to 865
Antenna gain (nominal) (reference at preamp input and like polarization)	42.5 dB	29.5 dB
Antenna beamwidth (nominal)	1.0°	3.0°
Receiving system noise figure (nominal) (reference at preamp input and like polarization)	1.5 dB	3.2 dB
System noise temperature (nominal) (antenna plus receiving system referenced at preamp input)	240 K	475 K
System sensitivity; S = N (nominal) (based on receiver i-f bandwidth of 500 kHz)	-118 dBm	-115 dBm

* Also down-converted outputs available at 300 to 400 MHz.
** Autotrack capability not available; receive only.

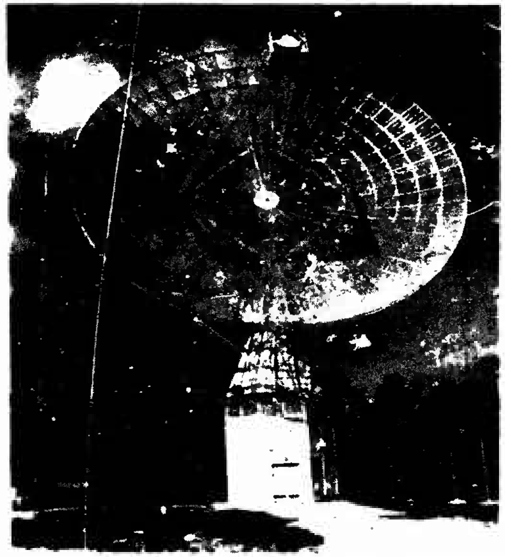
AT-36 TELEMETRY

TABLE 2-17
AT-36/PRETORIA TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	Paraboloid
Size	60-ft diameter
Feed	Apex, dual log periodic conical spirals, conical scan
Scan rate	10 Hz
Pedestal	Elevation over azimuth
Pointing error	±0.1° static plus dynamic of 0.02° per deg/s
Tracking velocity	10°/s both axes (20°/s at zenith)
Tracking acceleration	7°/s/s both axes
Polarization	Right and left circular (simultaneous and selectable)
Frequency band	2200 to 2300 MHz (down-converted to 300-400 MHz)
Antenna gain (reference at preamp input)	44 dB (nominal)
Antenna beamwidth	0.5° (nominal)
Receiving system noise figure (reference at preamp input)	1.5 dB (nominal)
System noise temperature (antenna plus receiving system referenced at preamp input)	350 K (nominal)
System sensitivity; S = N (based on receiver i-f bandwidth of 500 kHz)	-116 dBm (nominal)

TABLE 2-18. TAA-2/GRAND BAHAMA TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	Paraboloid
Size	85-ft diameter
Feed	Apex, dual log periodic conical spirals, conical scan
Scan rate	10 Hz
Pedestal	Elevation over azimuth
Pointing error	±0.10° plus 0.05° per deg/s
Tracking velocity	10°/s max. (both axes)
Tracking acceleration	5°/s/s max. (both axes)
Polarization	Right & left circular (simultaneous & selectable)

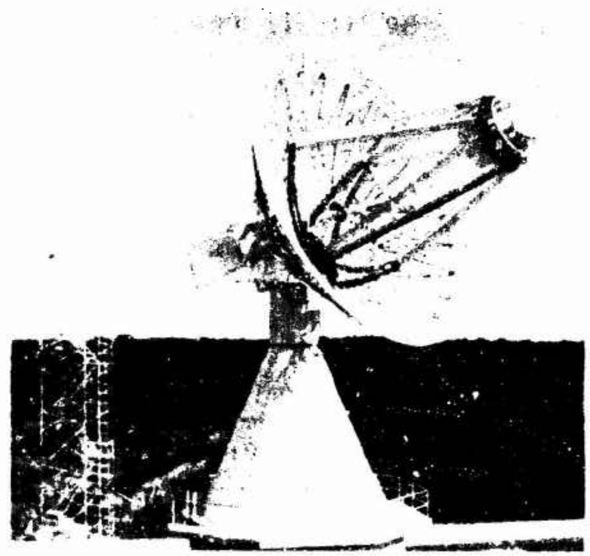


Frequency band (MHz)	*2200-2300	***1435-**1535	**920-960	**370-410	**285-315	225-260	**130-140
Antenna gain (nominal) (reference at preamp input & like polarization)	48 dB	45 dB	41 dB	33 dB	31 dB	29 dB	24 dB
Antenna beamwidth (nominal)	0.4°	0.6°	0.9°	2.1°	2.8°	3.5°	6.2°
Receiving system noise figure (nominal) (reference at preamp input)	1.5 dB	4.5 dB	5 dB	5 dB	5 dB	4 dB	3 dB
System noise temperature (nominal) (antenna plus receiving system reference at preamp input)	360 K	765 K	865 K	885 K	900 K	950 K	1540 K
System sensitivity: S = N (nominal) (based on receiver i-f bandwidth of 500 kHz)	-116 dBm	-113 dBm	-112 dBm	-112 dBm	-112 dBm	-112 dBm	-110 dBm

*Also down-converted outputs available at 300-400 MHz
**MPDL
***Frequencies down-converted to 300-400 MHz

TABLE 2-19. TAA-3A/TEL 4 TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	Paraboloid
Size	33-ft diameter
Feed	Apex, dual log periodic conical spirals, conical scan
Scan rate	10 Hz
Pedestal	Elevation over azimuth
Pointing error	±0.1° plus 0.03° per deg/s
Tracking velocity	15°/s (both axes)
Tracking acceleration	7°/s/s (both axes)
Polarization	Right & left circular (simultaneous & selectable



Frequency band (MHz)	*2200-2300	**1435-1535	***920-960	***370-410	***285-315	225-260	130-140
Antenna gain (nominal) (reference at preamp input & like polarization)	39 dB	36 dB	32 dB	25 dB	23 dB	21 dB	16 dB
Antenna beamwidth (nominal)	0.9°	1.3°	2.2°	5.0°	7.0°	8.0°	16°
Receiving system noise figure (nominal) (reference at preamp input)	3.8 dB	4.5 dB	5.0 dB	5.0 dB	5.0 dB	4.0 dB	3.0 dB
System noise temperature (nominal) (antenna plus receiving system referenced at preamp input)	645 K	765 K	865 K	885 K	900 K	950 K	1540 K
System sensitivity: S = N (nominal) (based on receiver i-f bandwidth of 500 kHz)	-113.5 dBm	-113 dBm	-112 dBm	-112 dBm	-112 dBm	-112 dBm	-110 dBm

*Also down-converted outputs available at 300-400 MHz.
**Frequencies down-converted to 300-400 MHz
***MPDL

TABLE 2-20. TAA-3A/GRAND BAHAMA TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	Paraboloid
Size	33-ft diameter
Feed	Apex, dual log periodic conical spirals, conical scan
Scan rate	10 Hz
Pedestal	Elevation over azimuth
Pointing error	±0.1° plus 0.03° per deg/s
Tracking velocity	15°/s (both axes)
Tracking acceleration	7°/s (both axes)
Polarization	Right & left circular (simultaneous & selectable)

Frequency band (MHz)	*2200-2300	**920-960	**370-410	**285-315	225-260
Antenna gain (nominal) (reference at preamp input)	39 dB	32 dB	25 dB	23 dB	21 dB
Antenna beamwidth (nominal)	0.9°	2.2°	5°	7°	8°
Receiving system noise figure (nominal) (reference at preamp input)	5 dB	5 dB	5 dB	5 dB	4 dB
System noise temperature (nominal) (antenna plus receiving system referenced at preamp input)	865 K	865 K	885 K	900 K	950 K
System sensitivity; S = N (nominal) (based on receiver i-f bandwidth of 500 kHz)	-112 dBm	-112 dBm	-112 dBm	-112 dBm	-112 dBm

*Frequencies down-converted to 300-400 MHz.
**MPDL

TABLE 2-21. TAA-3A/ANTIGUA TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	Paraboloid
Size	33-ft diameter
Feed	Apex, dual log periodic conical spirals, conical scan
Scan rate	10 Hz
Pedestal	Elevation over azimuth
Pointing error	±0.1° plus 0.03° per deg/s
Tracking velocity	15°/s (both axes)
Tracking acceleration	7°/s/s (both axes)
Polarization	Right & left circular (simultaneous & selectable)

Frequency band (MHz)		*2200-2300	**920-960	**370-410	**285-315	225-260	**130-140
Antenna gain (nominal) (reference at preamp input & like polarization)		39 dB	32 dB	25 dB	23 dB	21 dB	16 dB
Antenna beamwidth (nominal)		0.9°	2.2°	5°	7°	8°	16°
Receiving system noise figure (nominal) (reference at preamp input)		5 dB	5 dB	5 dB	5 dB	4 dB	3 dB
System noise temperature (nominal)(antenna plus receiving system referenced at preamp input)		865 K	865 K	885 K	900 K	950 K	1540 K
System sensitivity; S = N (nominal) (based on receiver i-f bandwidth of 500 kHz)		-112 dBm	-112 dBm	-112 dBm	-112 dBm	-112 dBm	-110 dBm

*Frequencies down-converted to 300-400 MHz
**MPDL

TABLE 2-22. TAA-3A/ASCENSION TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	Paraboloid
Size	33-ft diameter
Feed	Apex, dual log periodic conical spirals, conical scan
Scan rate	10 Hz
Pedestal	Elevation over azimuth
Pointing error	±0.1° plus 0.03° per deg/s
Tracking velocity	15°/s (both axes)
Tracking acceleration	7°/s/s (both axes)
Polarization	Right & left circular (simultaneous & selectable)

Frequency band (MHz)	*2200-2300	**920-960	**370-410	**285-315	225-260
Antenna gain (nominal) (reference at preamp input)	39 dB	32 dB	25 dB	23 dB	21 dB
Antenna beamwidth (nominal)	0.9°	2.2°	5°	7°	8°
Receiving system noise figure (nominal) (reference at preamp input)	3.8 dB	5 dB	5 dB	5 dB	4 dB
System noise temperature (nominal) (antenna plus receiving system referenced at preamp input)	645 K	865 K	885 K	900 K	950 K
System sensitivity; S = N (nominal) (based on receiver i-f bandwidth of 500 kHz)	-113.5 dBm	-112 dBm	-112 dBm	-112 dBm	-112 dBm

*Also down-converted outputs available at 300-400 MHz.
**MPDL

TABLE 2-23
4-FT BROADBEAM ANTENNA/ASCENSION
TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	4-ft diameter with cavity backed crossed dipole apex feed
Pedestal	Elevation over azimuth
Slew rates	11°/s (both axes)
Pointing accuracy	±1.0°
Polarization	Right and left circular (simultaneous and selectable)
Frequency band	785 to 865 MHz
Antenna gain (reference at preamp input and like polarization)	15.0 dB (nominal)
Antenna beamwidth	17° (nominal)
Receiving system noise figure (reference at preamp input)	3 dB (nominal)

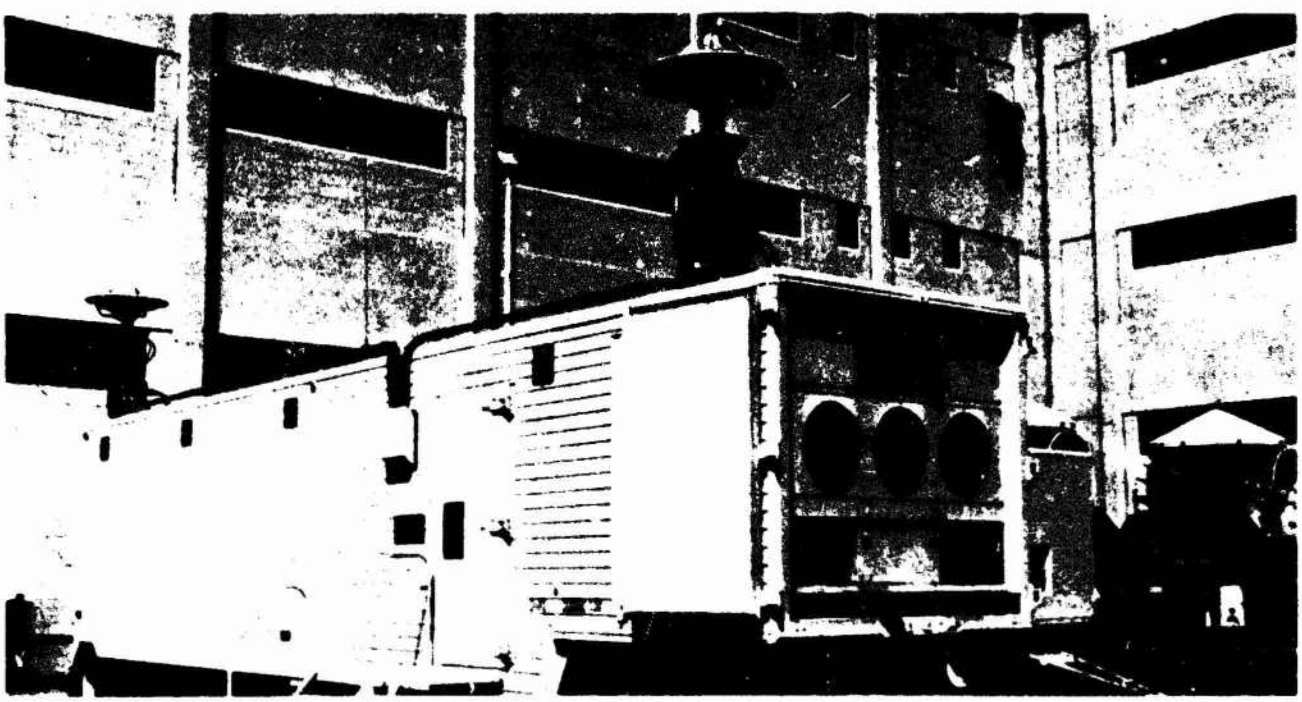
TABLE 2-24
3-FT BROADBEAM ANTENNA/ASCENSION
TELEMETRY TECHNICAL CHARACTERISTICS

Antenna	3-ft diameter parabola with single log periodic conical spiral apex feed
Pedestal	Elevation over azimuth
Slew rates	11°/s (both axes)
Pointing accuracy	±1.0°
Polarization	Right circular
Frequency band	2200-2300 MHz (down-converted to 300-400 MHz)
Antenna gain (reference at preamp input and like polarization)	21 dB (nominal)
Antenna beamwidth	10° (nominal)
Receiving system noise figure (reference at preamp input)	5 dB (nominal)

TABLE 2-25
BROADBEAM ANTENNA/TEL-4 TELEMETRY
TECHNICAL CHARACTERISTICS

Antenna	3-ft diameter parabola with single log periodic conical apex feed & 3 nine-turn helix mounted on a ground plane	
Pedestal	Elevation over azimuth	
Slew rates	11°/s (both axes)	
Pointing accuracy	±1.0°	
Polarization	Right circular	
Frequency band (MHz)	*2200 to 2300	225 to 260
Antenna gain (nominal) (reference at preamp input and like polarization)	21 dB	14 dB
Antenna beamwidth (nominal)	10°	35°
Receiving system noise figure (nominal) (reference at preamp input)	5 dB	5.5 dB

*Frequencies down-converted to 300-400 MHz



MOBILE TELEMETRY VAN

TABLE 2-26
MOBILE TELEMETRY VAN, PARABOLIC ANTENNA,
TECHNICAL CHARACTERISTICS

Antenna	3-ft diameter parabola with cavity-backed crossed-dipole apex feed	
Pedestal	Elevation over azimuth	
Slew rates	Elevation – 3°/s Azimuth – 7°/s	
Pointing accuracy	– ±1°	
Polarization	Right and left circular (simultaneous and selectable)	
Frequency band (MHz)	*2200-2300	*1435-1535
Antenna gain (nominal) (reference at preamp input and like polarization)	20.5 dB	17 dB
Antenna beamwidth (nominal)	11°	16°
Receiving system noise figure (nominal) (reference at preamp input)	4 dB	4 dB

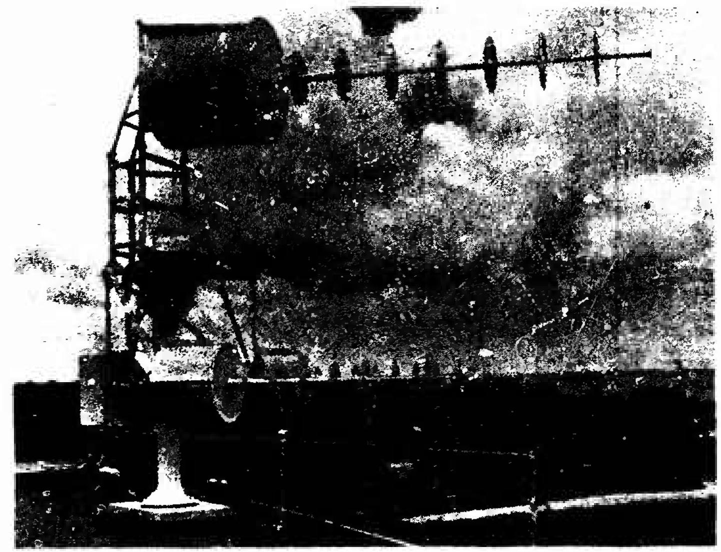
*Frequencies down-converted to 300-400 MHz.

TABLE 2-27
MOBILE TELEMETRY VAN, CROSSED-DIPOLE ANTENNA,
TECHNICAL CHARACTERISTICS

Antenna	Omni, crossed-dipole overground plane	
Pedestal	Fixed	
Polarization	Right and left circular (selectable)	
Frequency band	*2200-2300	*1435-1535
Antenna gain (nominal) (reference at preamp input and like polarization)	3 dB at zenith -5 dB at +10° el	3 dB at zenith -5 dB at 10° el
Antenna beamwidth (azimuth)	Omnidirectional	Omnidirectional
Receiving system noise figure (nominal) (reference at preamp input)	4 dB	4 dB

*Frequencies down-converted to 300-400 MHz.

TABLE 2-28. TAM-1/TEL-4 TELEMETRY TECHNICAL CHARACTERISTICS



Antenna . . . . Array consisting of 4 disk-on-rod antennas for frequencies 130-410 MHz and (3) conical horns for frequencies 920 to 2300 MHz

Pedestal . . . . Azimuth
Slew rate . . . . 8^{o}/s
Pointing accuracy . . . . ±1.0°
Polarization . . . . Right & left circular (selectable)

Frequency band (MHz)	*2200-2300	*1435-**1535	**920-960	**370-410	**285-315	**225-260	130-140
Antenna gain (nominal) (reference at preamp input & like polarization)	12 dB	12 dB	12 dB	12 dB	12 dB	12 dB	12 dB
Antenna beamwidth (nominal)	32°	32°	32°	32°	32°	32°	32°
Receiving system noise figure (nominal) (reference at preamp input)	5 dB	5 dB	8.5 dB	6.5 dB	5.5 dB	4 dB	3.5 dB

*Frequencies down-converted to 300-400 MHz
**MPDL

2.3 OPTICS

2.3.1 Metric Optics

There are basically four optical instrumentation systems in use at the ETR for obtaining metric data. Three are conventional camera systems which include the cinetheodolite, ballistic camera, and the fixed ribbon-frame camera. The fourth is a laser ranger.

The ETR laser ranger, capable of obtaining high-precision range measurements, has a mount which can be driven with pointing information obtained either from nominal vectors or real-time radar data. This system is currently used in triangulation nets consisting of four lasers, three NASA laser rangers, and the ETR laser ranger, in support of the GEOS-C satellite program (the NASA laser rangers are located at Grand Turk Island; Wallops Island, Virginia; and Bermuda).

Using camera systems to obtain missile or vehicle data requires the independent orientation of each camera to be used in the triangulation net, and determining the most probable spatial position by the intersection of directed rays from each of the separate camera stations. Position errors are a function of the random error of the fundamental measurement and of the geometry of the triangulation net.

Geometry of the triangulation net is a consideration of the location of each camera station with respect to the position point of interest, focal length of each camera, direction of the optical axis of each camera, and primarily the angle of intersection of the rays in space.

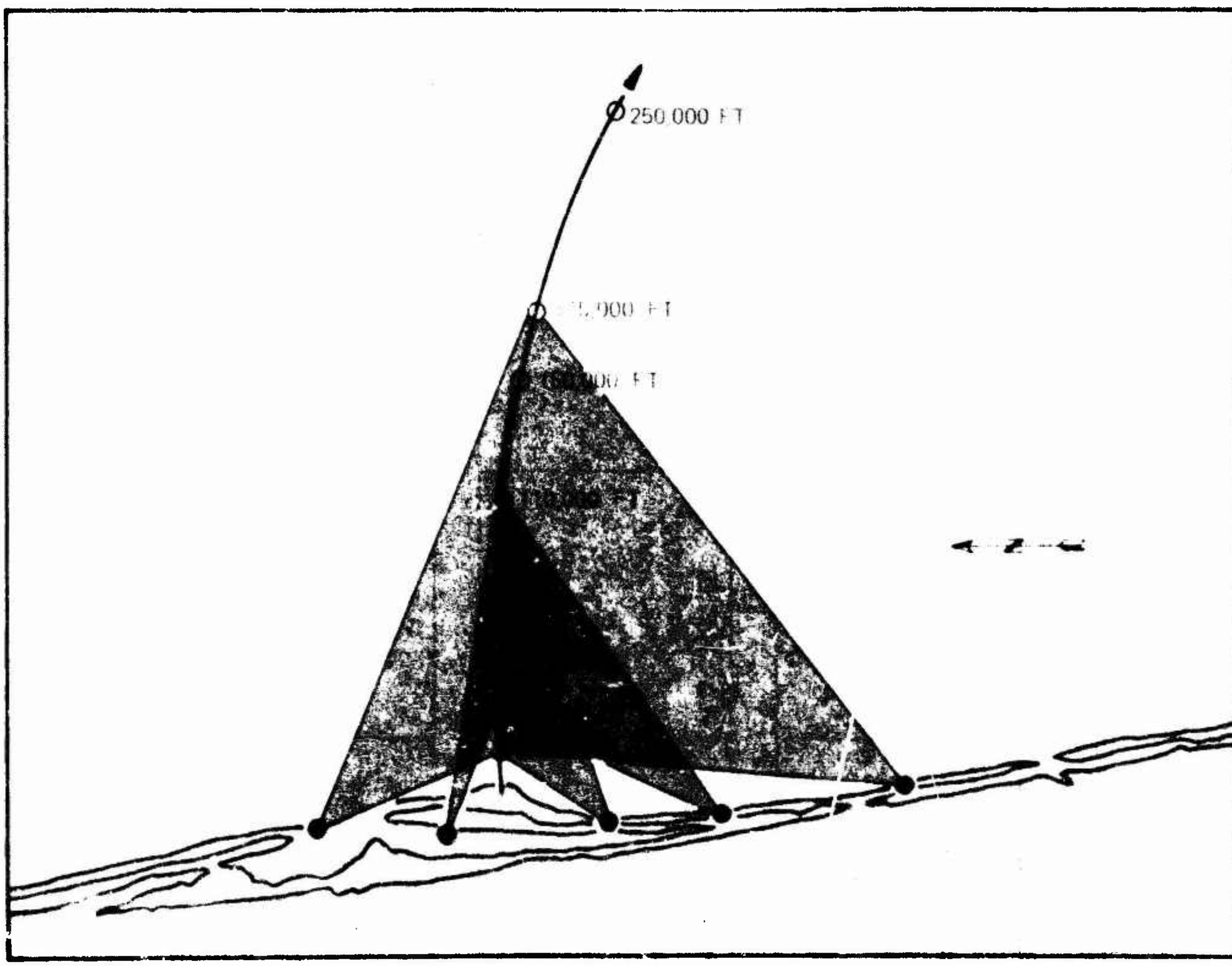


Figure 2-3. Typical Launch Phase Optics Coverage

TABLE 2-29. ETR METRIC OPTICAL INSTRUMENTATION SUMMARY

Type	Qty	Location	Focal Length	Film/Frame Format	Frame/Shutter Rate	Max Tracking Rate (deg/s)	Typical System Error (arcsec)
CINETHEODOLITES							
Askania KTH-53	3	Mobile	12, 24, 40 in	Double 35-mm	1, 2, 5 f/s	10	21
Askania KTH-53	1	Cape	12, 24, 40 in	Double 35-mm	1, 2, 5 f/s	10	21
Contraves E	6	Mobile	60, 120 in	Single 35-mm	5, 10, 20, 30 f/s	30	14
BALLISTIC CAMERAS							
Wild BC-4	2	USNS Redstone	300 mm	190 x 215 mm plate	4 p/s max	NA	2.4
Wild BC-4	6	Ascension	450 mm	190 x 215 mm plate	10 p/s max	NA	2.0
Wild BC-4	4	USNS Arnold*	300 mm	190 x 215 mm plate	4 p/s max	NA	2.4
Fairchild K-19B	4	USNS Vandenberg	12 in	190 x 215 mm plate	2 p/s max	NA	60
RIBBON FRAME CAMERAS							
CZR-1 RC-4		Mobile	6, 8.25, 10, 20 in	1.0 x 5.25 in max	36, 60, 90, & 180 f/s	NA	18
CZR-1 RC-5A		Cape	6, 8.25, 10, 20 in	1.0 x 5.25 in max	36, 60, 90, 180 f/s	NA	18

LASER RANGER (RAMLAS)

Type	Qty	Location	Telescope Focal Length	Telescope Aperture	Mount Drive	Exit Beam Width	Beam Divergence	PRF
Q-Switch Ruby	1	Patrick AFB/RML	Variable from 240-560 in	24 in	Computer Radar Manual	15 cm	0.75 mrad	1 p/s

*Either of the two Advanced Range Instrumentation Ships (ARIS) can accept a set of four of the BC-4 cameras.

The ETR presently has 57 land-based sites for fixed camera systems, 24 sites for the mobile cinetheodolites, 16 universal sites which will accommodate any of the ETR mobile optics systems including cinetheodolites, and 8 ballistic camera sites. Additionally, optics systems are located on each of the three ETR range instrumentation ships. See table 2-29 for a summary of the ETR metric optics systems.

2.3.1.1 Cinetheodolites

The cinetheodolite is a precision tracking instrument used to measure horizontal and vertical angles (azimuth and elevation) of a line of sight. An object along the path of flight trajectory is manually tracked using exterior sighting telescopes. The primary telescopic objective acquires the data to be recorded. The camera photographically

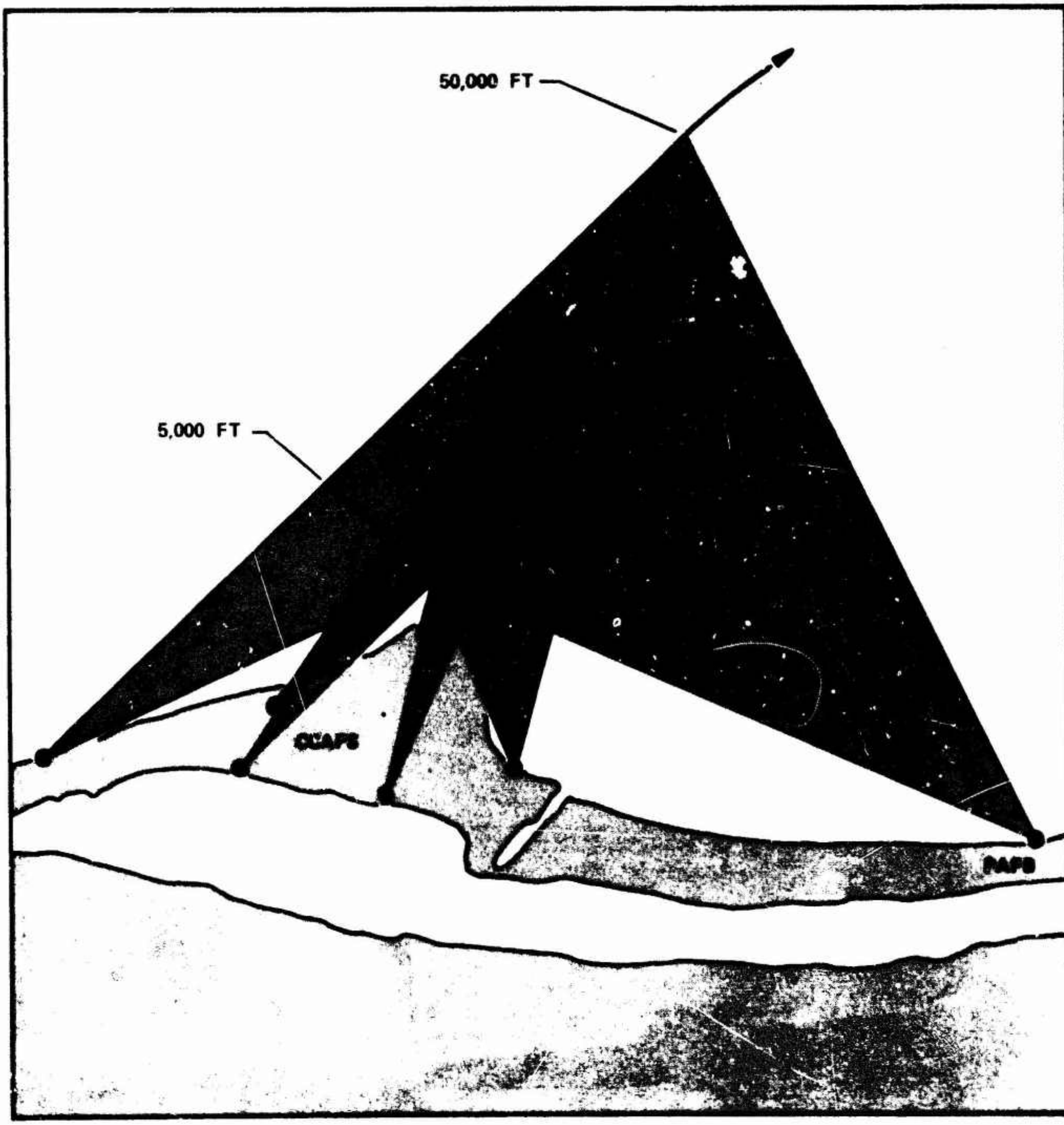


Figure 2-4. Typical Cinetheodolite Coverage

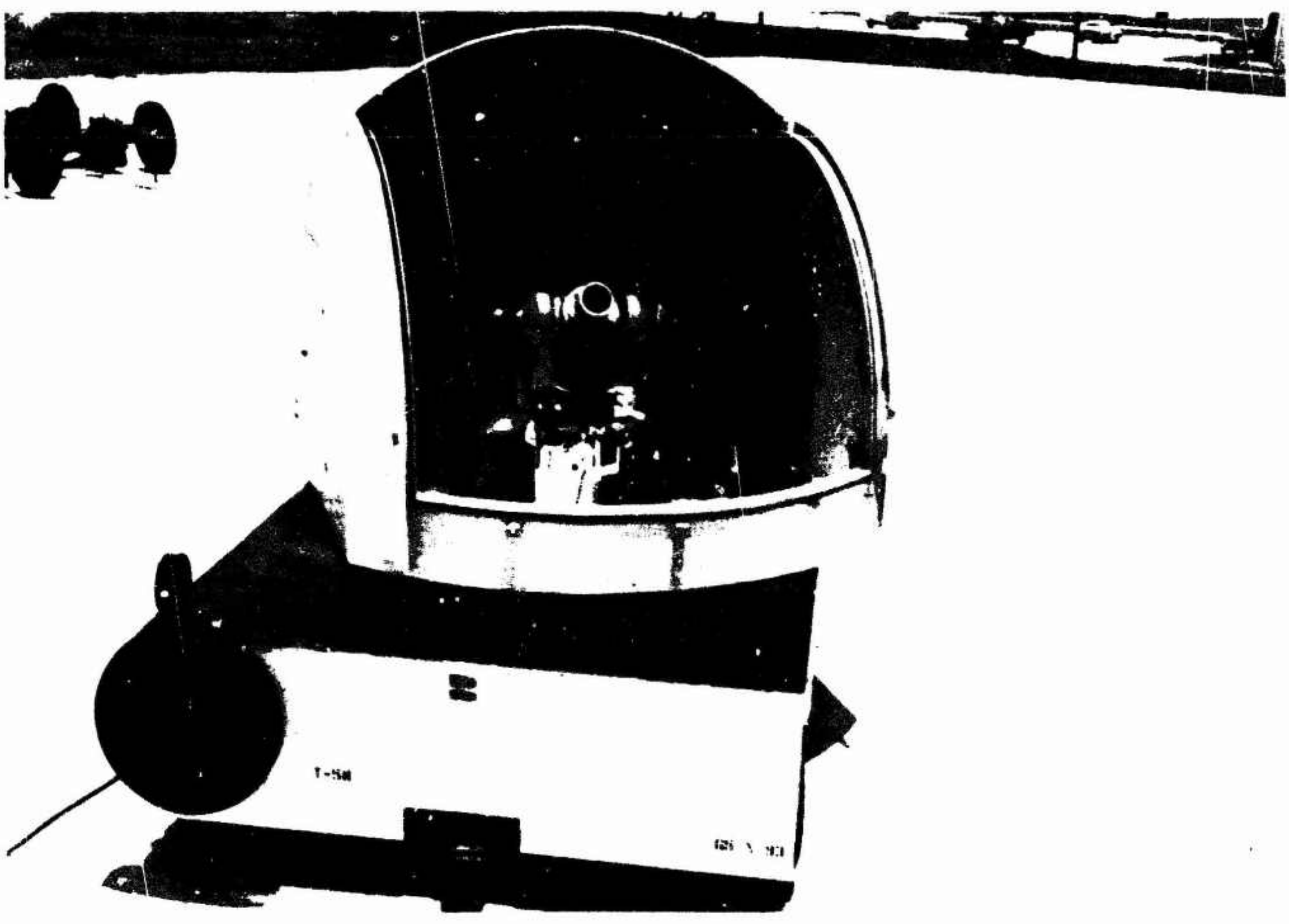
records the object in flight, together with the azimuth and elevation dials, at specific time intervals. With the measurements from two or more instruments at different ground positions, it is possible to determine the spatial position of the object being tracked.

Triangulation with the cinetheodolite system does not exactly use the orientation of the instrument, but rather uses the direction of the ray in space to the object being tracked. This direction is determined by applying a tracking correction (as determined by film measurements) to the azimuth and elevation of the optical axis as read from the dial recordings.

The cinetheodolites cover missile flights from approximately 500 to 100,000-ft altitude, and are a main source of trajectory measurement data from 1,000 to 50,000-ft altitude in the Cape area. The Askania KTH-53 and Contraves Model E are used at the ETR. Typical cinetheodolite system coverage is shown on figure 2-4.

The Askania KTH-53 uses a 35-mm double frame camera movement for data recording. One operator manually tracks the target in azimuth and elevation. Pulses from central timing operate all the cameras at the selected frame rate to ensure that all instruments record data at the same time. Electronic controls at each site also synchronize the strobe lamps which provide light for the azimuth and elevation dials. The film records images of the target, azimuth and elevation dials, binary time code, and frame count.

Film is sent to Patrick AFB for processing and is read on a theodolite film reader. The reader produces digitized azimuth and elevation plotting angles of the cinetheodolite and tracking error XY coordinates of missile image position (with respect to the center of the film frame). Film reader



ASKANIA KTH-53 CINETHEODOLITE

output is recorded on paper tape and later converted to magnetic tape for postflight reduction of position, velocity, and acceleration data.

ASKANIA KTH-53 TECHNICAL CHARACTERISTICS

Exposure time	Fixed at 1/150 s using a venetian-blind shutter
Camera drive	Pulse-operated mechanism
Frame rate	1, 2, or 5 frames per second (selected by a master station)
Film format	Double 35-mm format (1-½ x 1 in)
Film load and running time	125-ft magazine load with 140 s running time at 5 f/s
Lenses available	12, 24, and 40-in focal lengths
Timing	Binary code and frame count are recorded on the 35-mm film
Maximum angular tracking rate	About 10°/s
Sighting telescope	20X elbow-sighting scope permits scope to rotate about eyepiece
Accuracy	Typical random errors in angles of a single cinetheodolite are 9 seconds of arc. Systematic errors are about 21 seconds of arc.

Three Askanias are mobile and may be located at several universal (all-purpose) camera sites. A fourth unit is mounted in an astrodome-tower configuration.

The Contraves Model E cinetheodolite uses a 35-mm single frame camera for data recording. The film records images of the target, azimuth and elevation angle information in biquinary digital forms, and coded digital timing.

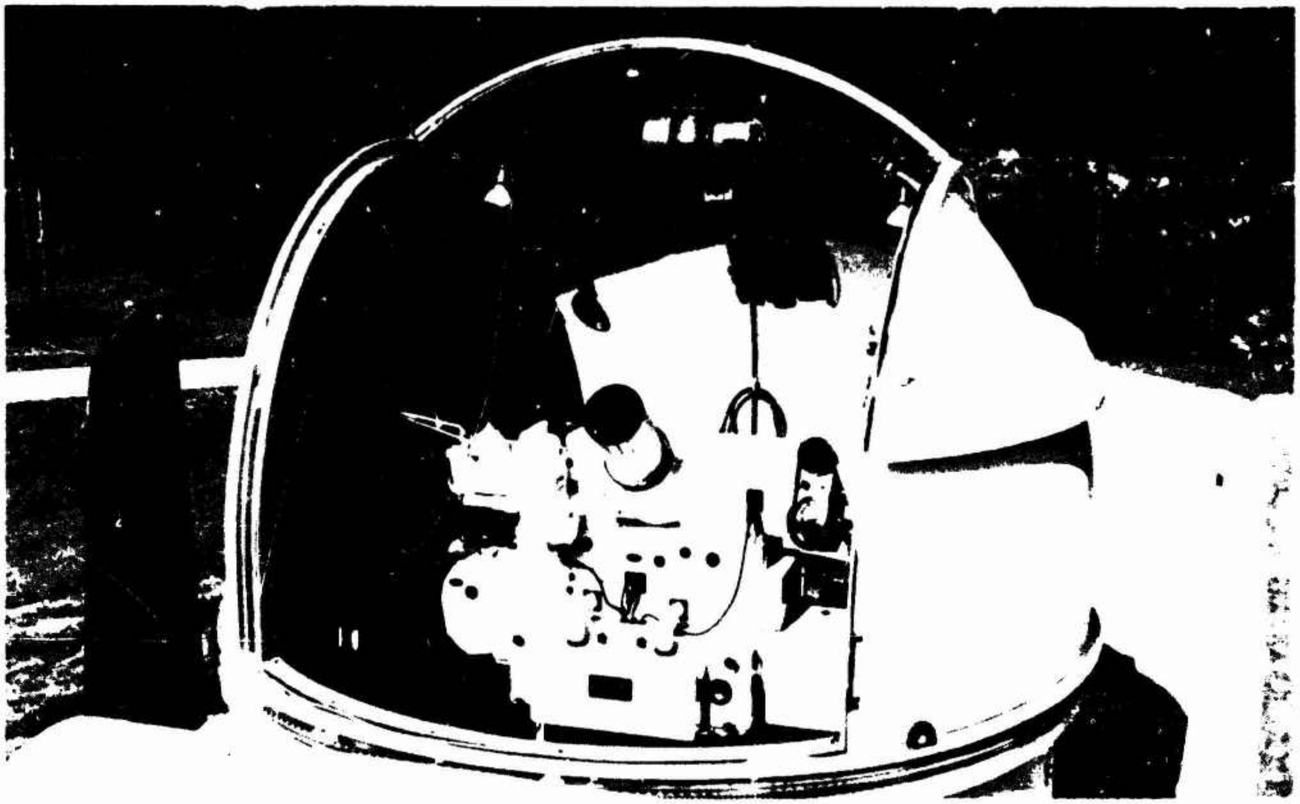
One operator tracks the target in azimuth and elevation with a joystick controlling an angle-speed-acceleration type power-driven tracking system. This system allows smooth and precise tracking, free from the high momentary accelerations and corresponding flexure of the optical system and disturbance of the level of the instrument, characteristic of manual tracking.

A closed-circuit television system, with the pickup camera mounted on the cinetheodolite and collimated with the objective, allows the Contraves cinetheodolite to be remotely controlled, permitting its operation in the danger area.

CONTRAVES TECHNICAL CHARACTERISTICS

Film	35-mm single frame format (¾ x 1 in)
Magazine	400-ft capacity
Frame rates	5, 10, 20, and 30 f/s
Focal lengths	60 in at f/8 120 in at f/16
Focusing	Infinity to 2000 ft for 60-in lens Infinity to 8000 ft for 120-in lens
Sighting telescope	12 power with 5.5° field of view 20 power with 3.0° field of view
Leveling	To 2 seconds of arc
Synchronization	All instruments to 100 μs
Velocity	Less than 0.015°/s to 30°/s
Acceleration	$0°/s^2$ to $45°/s^2$
Digital encoding (Az/El)	Binary code recorded on the 35-mm film
Static accuracy	5 seconds of arc, including compensation for systematic errors
Dynamic accuracy	14 seconds of arc

The ETR has six Contraves E cinetheodolites. All are mobile. A trailer transports the cinetheodolite, the shelter, and all the necessary support and accessory equipment. These cinetheodolites may be placed for optimum launch coverage at universal camera sites. Fixed illuminated target arrays (out-of-focus and collimator lenses) provide zero reference for the Contraves.



CONTRAVES CINETHEODOLITE

2.3.1.2 Ballistic Cameras

Ballistic cameras, which have fixed focal length and wide angle lens systems, provide the most accurate means available for obtaining time-position data on an object in space. While atmospheric refraction imposes severe limitations upon the absolute accuracies ultimately obtainable from all other tracking systems, it causes no noticeable degradation of ballistic camera accuracies as long as the points observed are outside the effective atmosphere.

The exact fixed orientation of the camera is determined by time correlated exposures of star trails on a photographic glass plate. On the same plate, exposures are made of whatever object is being measured. The position of the object is then reconstructed using photogrammetric triangulation or resection techniques.

In addition to providing highly accurate trajectory data, other applications of the ballistic camera include geodetic survey; satellite observations; the recording of reentry phenomena; and recording of continuous flame traces, particularly to provide points of burnout and ignition of multistage rockets.

The Wild BC-4 is used by the ETR on its land stations and ships whereas the Fairchild K-19B aerial cameras are presently used only on the Advanced Range Instrumentation Ships (ARIS).

The Wild BC-4 cameras are used in groups established along suitable base lines to look at a

common point of interest. The BC-4 has a 2-axis mount for support and presetting to the desired orientation (the exact orientation is determined from star images). A camera shutter programmer drives the capping shutter through the desired sequences of exposures for the star trail and data point recording. Each shutter operation time is recorded so the star position can be referenced by sidereal time to its right ascension and declination position and so image points may be correlated from camera to camera.

BC-4 TECHNICAL CHARACTERISTICS

Film Plate

Type . . . . Eastman 103-F glass plate

Thickness . . 6-mm, flat to 6 wavelengths of sodium light

Size . . . . . 190x210 mm with 180x80 mm usable image area

Speed . . . . 100 ASA

Resolution . . . . 60-70 lines/mm

Lens

Focal length (mm)	300	450
Angular field (deg)	33	22
Aperture (mm)	117	117
F-stop	2.6	2.6

Accuracy

Angular errors of triangulation average 2.4 arsec for the 300-mm camera and 2.0 for the 450-mm camera.

The current distribution of BC-4 cameras is tabulated on table 2-29; however, a number of surveyed sites are available throughout the eastern U.S. and the ETR. New sites can be established with little facilities work.

The Advanced Range Instrumentation Ship (ARIS) USNS Vandenberg has an array of four fixed Fairchild K-19B cameras. The array consists of two ballistic cameras and two ballistic spectrographs. These instruments are modified K-19B aerial cameras. The lens iris of each instrument is automatically controlled during a mission to provide alternating exposures of 1/2 second at f/4 and 1/2 second at f/16. This sequential event is recorded on time-referenced paper charts. The normal iris control sequence can be manually interrupted during a mission to allow time correlation with photographic images. One camera and one spectrograph are focused for and operated with Kodak 1-N infrared emulsion, while the other camera and spectrograph utilize Kodak 103-F visible emulsion. The ballistic spectrographs use a 300 lines/mm transmission grating.

Normally, ballistic camera plates are used for overall event documentation, object identification, target malfunction identification, etc., and as an aid to interpreting the spectrograph plates. Ballistic cameras are also used to record metric data on objects outside the radar beams. The ballistic spectrographs are the sole source of spectral data on nontracked objects.

BC-4 BALLISTIC CAMERA

FAIRCHILD K-19B
TECHNICAL CHARACTERISTICS

Film Plates

Eastman glass plates, emulsions 1-N and 103-F (same plate characteristics as Wild BC-4 cameras)

Lens

Focal length (in) 12

Angular field (deg) 35

Aperture (mm) 75

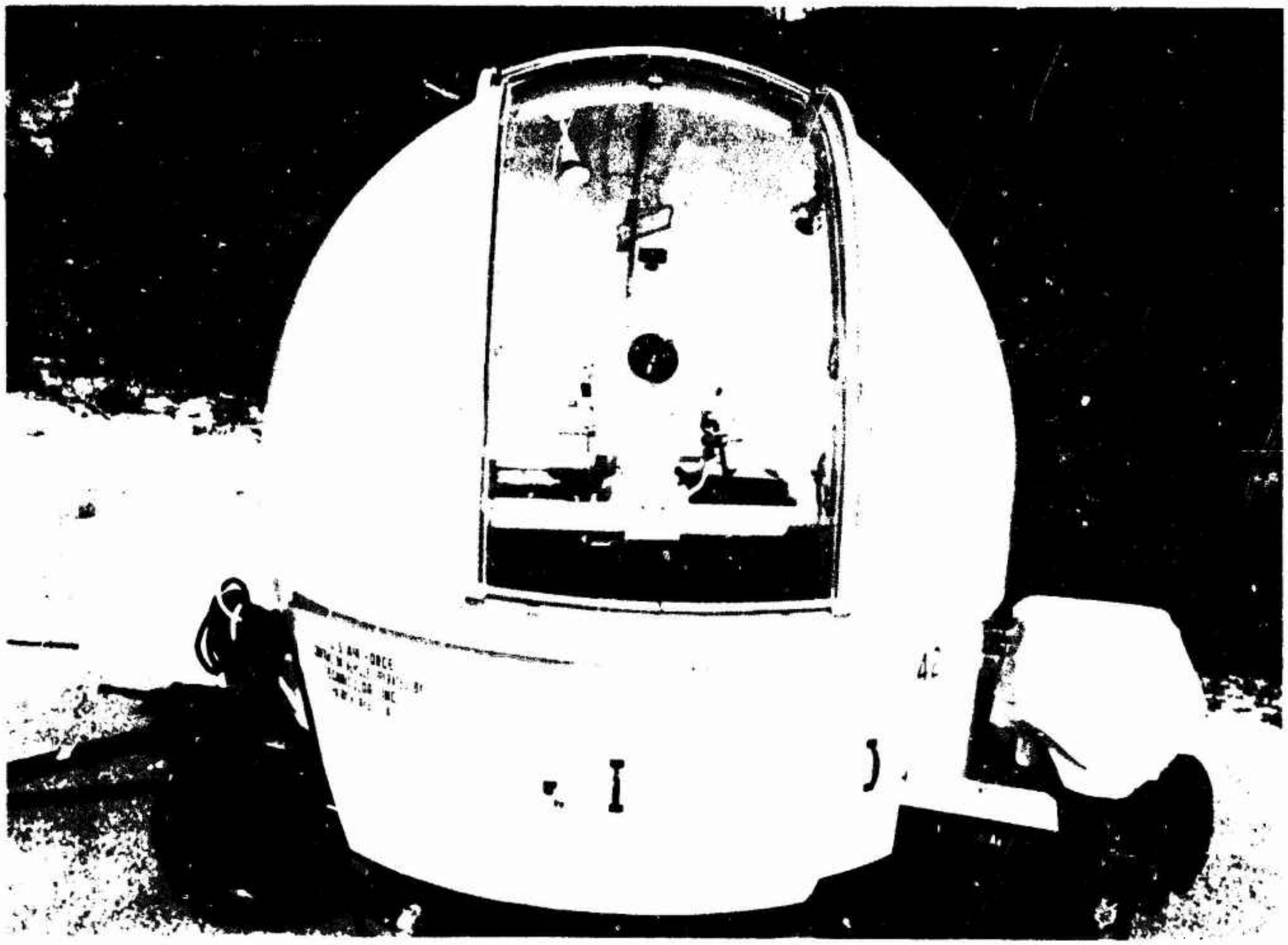
F-stop f/4, f/16

Accuracy . . System accuracy approx 1 arc minute

The array of four K-19B cameras is presently mounted on the same deck with the inte..iediate focal length optical telescope (IFLOT) on the USNS Vandenberg. The USNS Arnold presently has an array of four BC-4 cameras; however, these arrays are readily interchangeable between these ships.

2.3.1.3 Ribbon Frame (CZR) Camera

The standard fixed metric camera systems at the ETR are the CZR, RC-5, and RC-5A, which are functionally identical, but have minor design differences. The CZR is operated in a fixed orientation to obtain maximum coverage over the desired portion of the trajectory. Triangulation is performed using two through four camera combinations with the best geometry obtainable under field conditions.



CZR CAMERA

The fixed metric camera system records early launch trajectory of missiles for the first thousand feet of missile flight from which position, velocity, and acceleration data can be reduced. Roll, pitch, and yaw data can also be obtained.

CZR cameras are mounted on 3-axis precision gimbal mounts inside an air conditioned astrodome on a four-wheel trailer. An electronic driver unit performs sequencing and start functions, and supplies timing pulses for recording on the edge of the film in response to signals from a central timing source. The cameras may be started remotely from the complex blockhouse sequencer or may be started manually on the site.

The CZR utilizes roll film passing over a cylindrical drum focal plane. The shutter is an open slit in a second cylindrical drum rotating around the film drum and having a focal plane shutter effect on the surface of the film. Both the film and shutter drums rotate at a constant, but different rate. The number of frames per second depends upon shutter drum openings. The shutter drum has six slots, spaced 60° apart, which may be closed off by shutter slides. One open slot will give 30 f/s, two open slots opposite one another will give 60 f/s, three alternate open slots will give 90 f/s, and all slots open will give 180 f/s. Whenever the frame speed is changed, an aperture slide or framer must be inserted in the camera aperture to change the narrow dimension of the individual picture. The focal plane shutter drum is directly coupled to its synchronous motor which operates at 1800 r/min. Exposure time can be varied only by changing the size of the shutter slits that slide into the shutter drum slots. These slides have appropriate slits to give 1/20,000 or a 1/40,000 second exposure.

TECHNICAL CHARACTERISTICS

Exposure time	1/20,000s is standard
Frame rate	30, 60, 90, or 180/s
Frame format	1.0 x 5-¼ in maximum. Narrow side varies with frame rate as follows: 30, 60, 90, and 180 f/s; 1, 15/32, 5/16, and 5/32 in.
Film load and running time	100-ft magazines allow 40 s running time. Film width is 5.481 in.
Lenses available	10-in Elgeet is standard. Some cameras are also equipped to use 9-¼-in Schneider or 6-in Metrogon.
Timing	Timing projectors with neon lamps imprint timing pips on edge of film. Correlation of timing to exposure is accurate to 1 ms or better.
Mount dials	Reading capability to 0.0005° (18 s)

The ETR has 14 CZR's, all mobile. Precisely surveyed sites are located only in the launch complex areas. For each launch the CZR cameras are positioned at sites selected to give the required coverage and optimum geometric solution. Surveyed target poles are used for accurate prelaunch and postlaunch orientation.

2.3.1.4 Laser Ranger

The ETR laser ranger system utilizes a Q-switch ruby laser transmitter and a modified Recording Optical Tracking Instrument (ROTI) telescope on a torque-driven mount equipped with 20-bit encoders. On-axis pointing data is supplied to the mount by a Sigma-7 computer Either nominal vectors or real-time tracking by the neighboring on-axis radar provide pointing information from the computer. The mount can also be driven in a manual mode for boresighting, static checks, etc.

TECHNICAL CHARACTERISTICS

Laser	Q-matrix ruby
Pulse width	5 ns
Exit beam diameter	15 cm
Beam divergence	0.75 mrad
Energy	0.5 joule
PRF	1 p/s
Telescope	Modified ROTI

Telescope focal length	Variable (present) from 240 in to 1,600 in
Telescope aperture	24 in
Mount	Modified Nike-Hercules
Mount drive modes	Computer, radar, manual

The ETR laser ranger is located at Patrick AFB at the Range Measurements Lab (RML). It is located close to the Sigma-7 computer and 0.13 on-axis radar, all a part of the RML complex. This instrumentation station, designated RAMLAS (RML laser), is part of the GEOS-C geodetic satellite tracking system network. The Atlantic Coast Network consists of Grand Turk Island, Bermuda, RAMLAS, Wallops Island, and Greenbelt, Maryland.

2.3.2 Engineering Sequential and Documentary Optics

The primary purpose of engineering photography is to provide test mission event-versus-time data such as umbilical disconnect, hold-down release, engine ignition, liftoff, and booster separation. Engineering photography also provides inputs for film reports and record keeping purposes.

Documentary photography is used primarily for historical documentation and public information. It is not necessarily launch related or time annotated as engineering sequential. The primary purpose of documentary coverage is to record the events of transport, assembly, erection, checkout, and launch of missile and space systems.

The ETR uses tracking mounts and telescopes for obtaining engineering photographic coverage (see table 2-30 for summary). The IFLOT and the MOTS (Mobile Optical Tracking System) are the tracking mounts presently used. Telescopes include the ROTI and the IGOR (Intercept Ground Optical Recorder) plus the Itek 48-in telescope operated by the Range Measurements Laboratory.

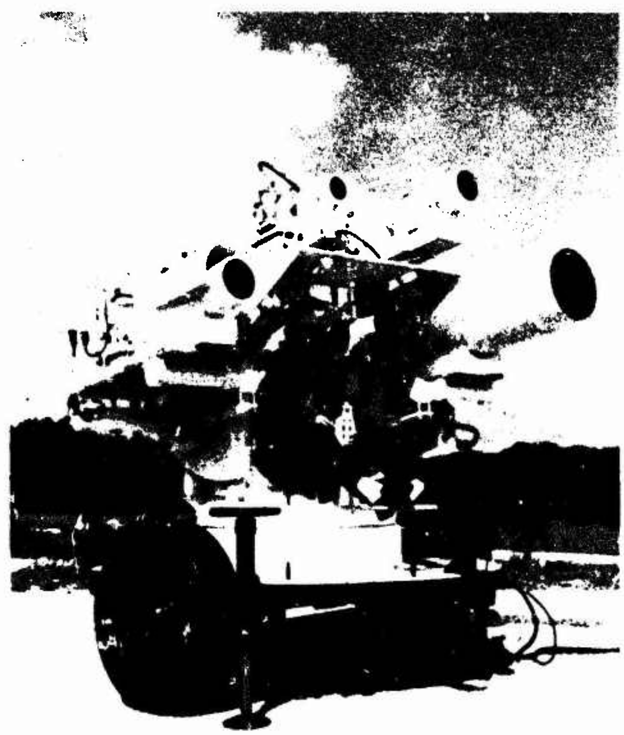
Numerous motion picture and still cameras are available at the ETR for engineering sequential and documentary photography. Included are 16-mm, 35-mm, and 70-mm motion picture cameras in addition to various type still cameras. These cameras are used in conjunction with tracking mounts or telescopes, in fixed positions, or hand-held in support of a broad range of photographic requirements.

2.3.2.1 IFLOT (Intermediate Focal Length Tracker)

The IFLOT can be configured with appropriate camera lens systems to obtain documentary, engineering sequential attitude, and signature data coverage. Ten IFLOT systems are available. These mobile trackers operate in the KSC/Cape Canaveral areas and at Ascension Island. The IFLOT's are also operated on support ships to cover sea launches and reentry phenomena.

The drive system has two enclosed oil-bath transmissions with preloaded tapered roller bearings, and is mounted on two-wheel trailers with precision jacks.

Each IFLOT accommodates up to four camera-lens combinations.



INTERMEDIATE FOCAL LENGTH TRACKER

TABLE 2-30. ETR TRACKING MOUNTS AND TELESCOPE SUMMARY

Type	Qty	Location	Focal Length Lens Accommodated	Focal Length	Aperture	Max Tracking Rate	Tracking Limits	Slave
MOUNTS								
IFLOT	10	Mobile	10–240 in			22°	−10° to +90° el 350°az	No
	1	USNS Arnold						
	1	USNS Vandenberg						
MOTS	2	Mobile	20-180 in			30°	−10° to +90° el 350° az	Yes
TELESCOPES								
RML/Itek	1	Malabar*		120, 240, 480 continuously variable to 7,000 in	48 in	15°	−10° to +190° el 720° az	Yes
ROTI	1	Melbourne Bh*		100, 200, 300, 400, 500 in	24 in	10°	−10° to +190° el 720° az	Yes
	1	Cocoa Bh*						
IGOR	1	Patrick AFB*		90, 180, 350, 500 in	18 in	10°	−3-1/2° to +92°	Yes
	3	Mobile						

*See figure 2-5.

TECHNICAL CHARACTERISTICS

Camera . . . . 16-, 35-mm Mitchell and 70-mm Photosonic or Hulcher

Focal length
lenses accommodated . . . . 10 to 240 in

Tracking rates
(elevation and azimuth) . . . . 22°/s

Angular
tracking limits . . . . 350° azimuth and -10 to +90° elevation

2.3.2.2 MOTS (Mobile Optical Tracking System)

The mobile optical tracking system (MOTS) is a remote controlled system for use within the launch danger zones. The system has an infrared tracker for automatic track and a closed-circuit television system for remote track. Each system consists of a pedestal trailer and a remote tracking console. Two camera-lens combinations may be used. The MOTS may be used outside of launch danger zones and can be operated at all KSC and most Cape Canaveral optical sites.

Two systems are in operation.

TECHNICAL CHARACTERISTICS

Tracking rate – maximum . . 30°/s velocity; 60°/s/s acceleration

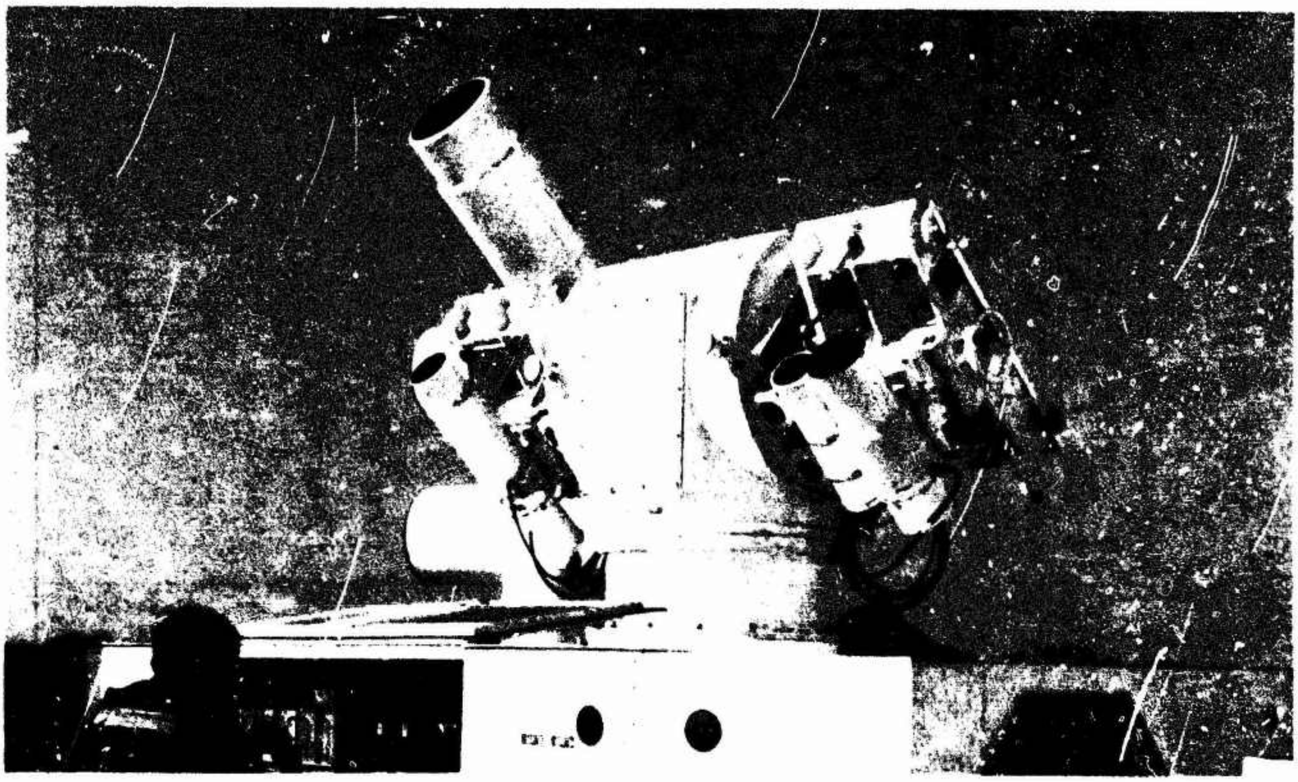
Focal length
lenses accommodated . . . . 20 to 180 in

Camera . . . . 16, 35, and 70 mm

TV . . . Vidicon tube with television monitor and joystick control for remote track by operator in tracking console trailer. IR (lead sulfide sensor) automatic tracking system with 1 to 20 miles range

Elevation range . . . . -10° to +90°

Azimuth range . . . . 350°



MOBILE OPTICAL TRACKING SYSTEM

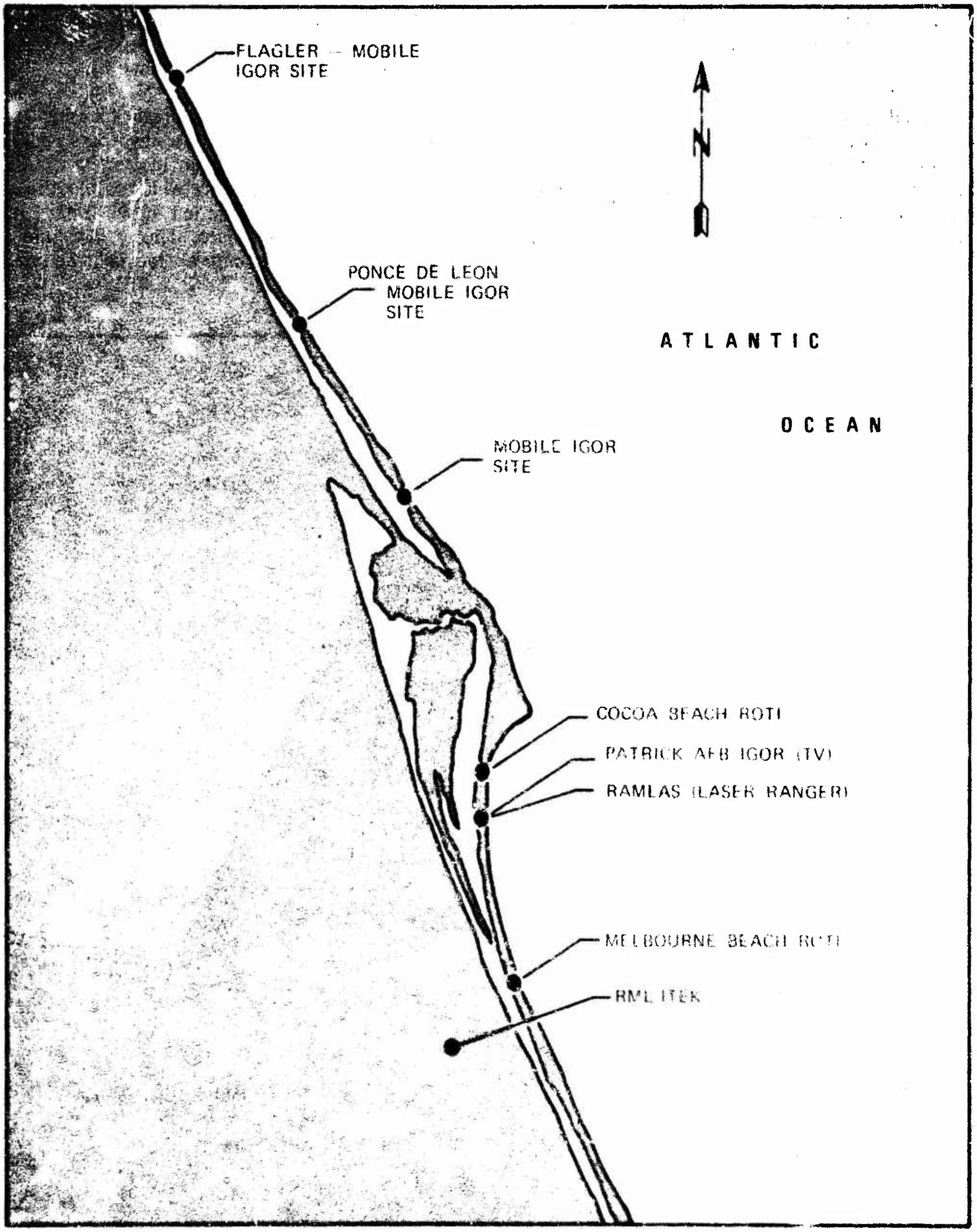


Figure 2-5 Locations of ETR Tracking Telescopes

2.3.2.3 ROTI (Recording Optical Tracking Instrument) (see figures 2-5 and 2-6)

The ROTI is a large tracking telescope system which takes time-correlated, high-resolution, long range photographs of objects in space. It uses a 100-in focal length Newtonian optical system. Focal length increases are provided by Biotar Relay lenses in increments of 100 in to a maximum of 500 in. The ROTI can provide up to 500 seconds of coverage (35-mm camera at 32 f/s).

The telescope is supported by a modified Navy Mk 30, 5-in gun mount driven by a hydraulic servo system for azimuth and elevation changes.

Controls are available for automatic focusing and exposure. The autofocus unit uses two glass wedges controlled by range data from the target acquisition bus. The exposure device which automatically maintains constant illumination at the film plane uses counter-rotating variable density discs and a photomultiplier that compares the light entering

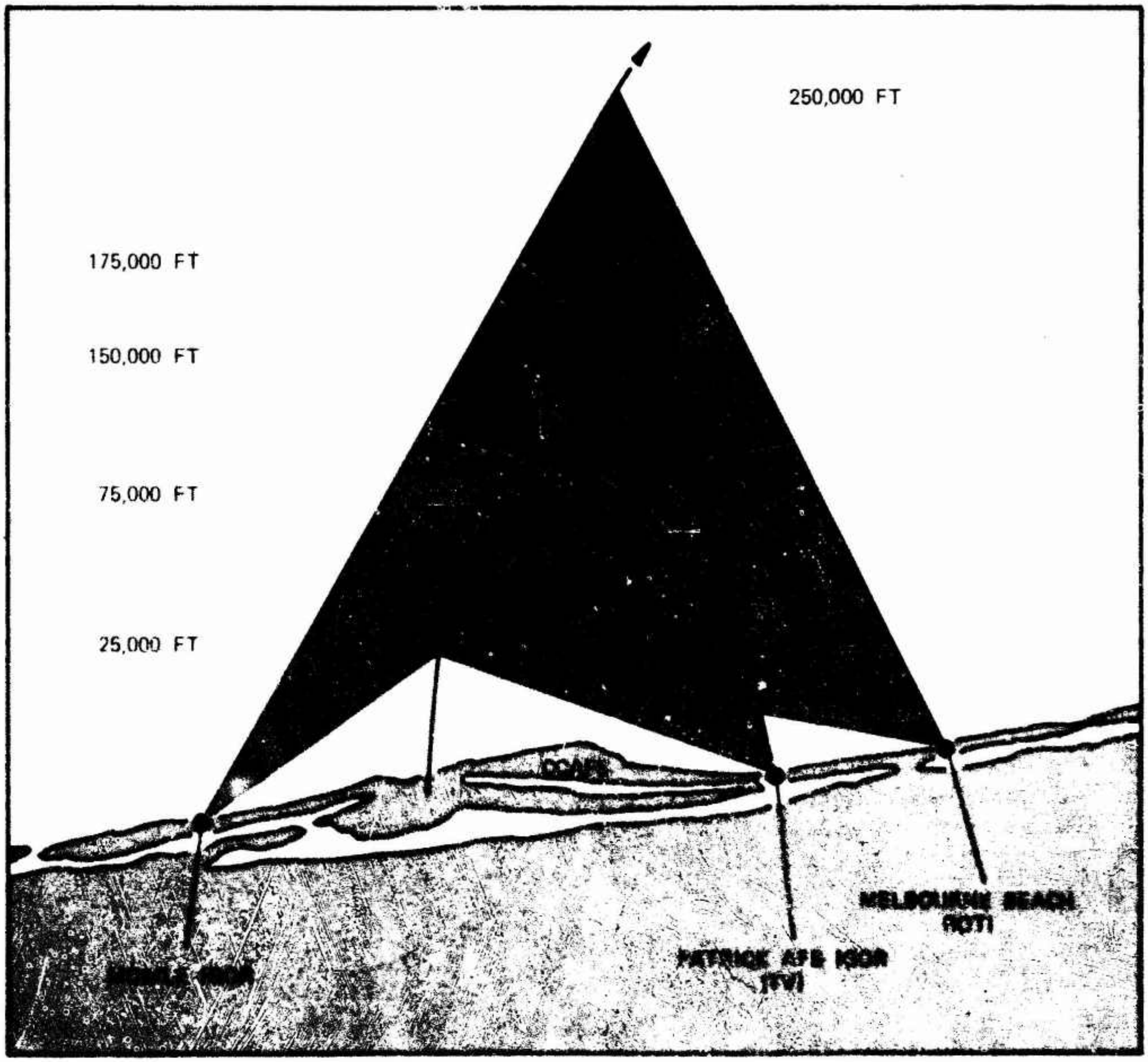


Figure 2-6. Typical Tracking Telescope Coverage

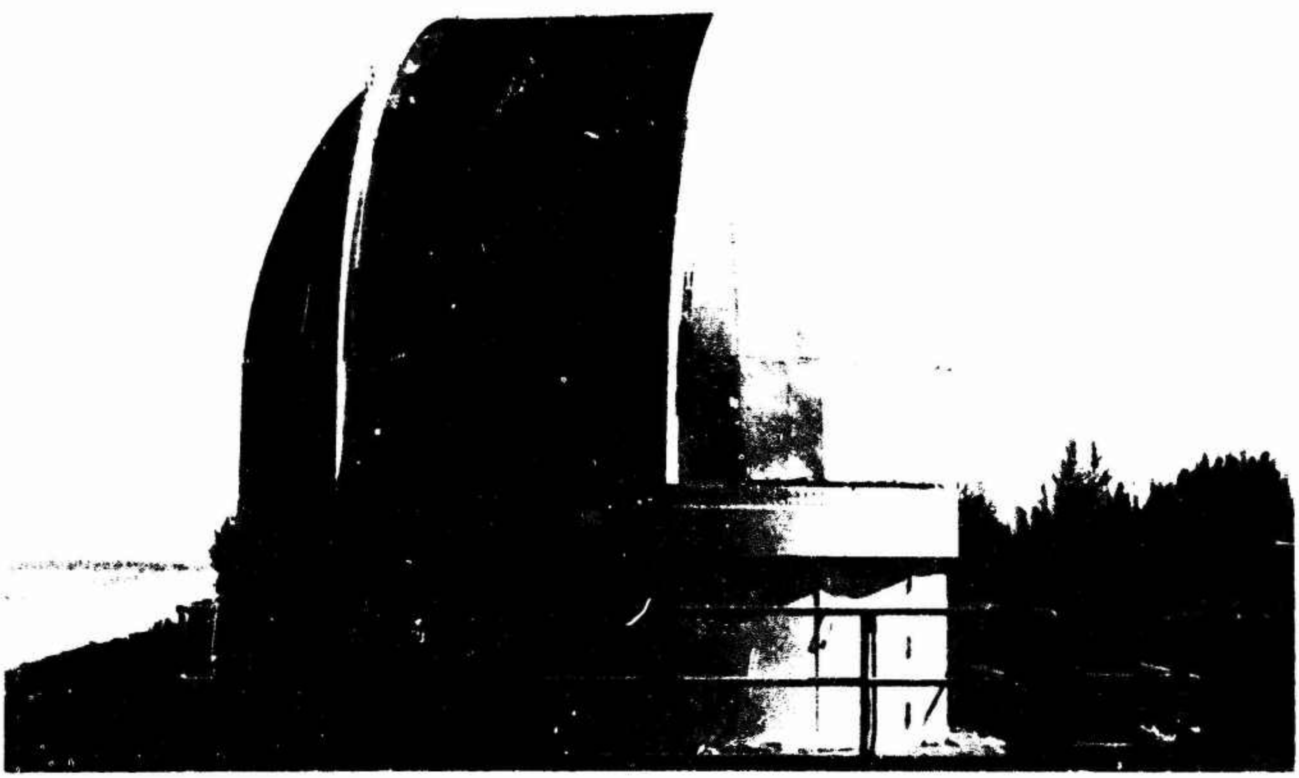
the telescope with that from a standard light source.

The ROTI is protected by a 15-ft weatherproofed, dehumidified dome atop a two-story tower, automatically positioned in azimuth by a drive assembly synchronized to the telescope rotation. A curved door slides overhead to expose the telescope. Three tracking modes are possible:

1. Slaved to the target acquisition bus through data receiver and coordinate converter.
2. Slaved operation with operator override (servo error voltages are presented to the operator for correction)
3. Operator tracking by stiff stick which permits control of position, velocity, and acceleration motions of the instrument in both axes. The instrument can also be oriented by cranking the handwheels (but not for missile tracking).

TECHNICAL CHARACTERISTICS

Film size	35 and 70 mm
Focal length	100, 200, 300, 400, and 500 in
Aperture	24 in
Magazine capacity	400 or 1,000 ft
Frame rates	10, 20, 30, 40, or 60 f/s (70 mm); 12 to 96 f/s (35 mm)
Tracking rate	10°/s maximum (increased by override function)
Angle limits	720° rotation in azimuth -10 to 190° elevation
Sighting telescope magnification	10, 20, and 40



RECORDING OPTICAL TRACKING INSTRUMENT

Visual null unit . . . . . CRT display with cross-hairs and a dot which moves according to the radar angular position data. This maintains track even though the target may not be visible.

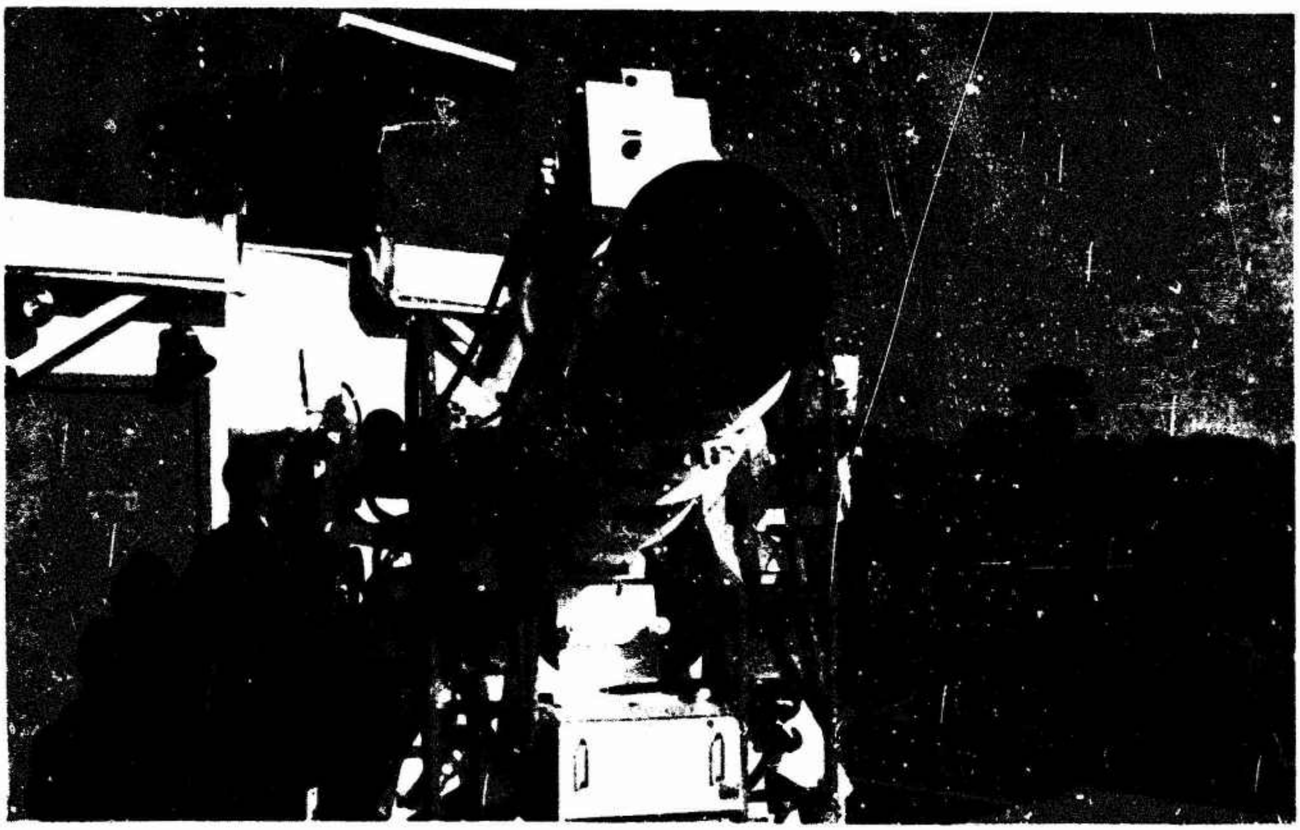
The ROTI is located at Melbourne Beach and Cocoa Beach (deactivated in-place status).

2.3.2.4 IGOR (Intercept Ground Optical Recorder) (see figures 2-5 and 2-6)

The IGOR is a tracking telescope system which takes time-correlated, high resolution, long range photographs of objects in space. It uses a modified Newtonian optical system, with a 90-in focal length. Amplifiers (Barlow type lenses) give added focal lengths of 180, 360, and 500 in. The telescope is mounted on a modified Navy Mk27, 5-in gun mount. The 70-mm Photosonics or the 35-mm Mitchell camera may be used.

The 35-mm and 70-mm motion picture cameras are adjustable for frame rate, shutter opening, and "off-on" operation. They use either 400 or 1,000-ft capacity dark-room-loading, daylight-threading magazines. They are equipped with variable shutters, timing lights, fiducial markers, film footage counters, and film runout switches.

An autofocus unit varies the focusing lens by a servo system. Servo input signals are derived from tracking radar information, corrected for parallax, and converted to slant range by coordinate converters. The coordinate converter takes X, Y, and Z data from a data receiver and converts it to azimuth and elevation voltages. Each azimuth and elevation tracking operator has a cathode-ray tube display which shows the error between the telescope aiming and radar target position data. The IGOR at Patrick AFB has an image orthicon TV system used for long range real-time and photo/optical coverage. The real-time television signal is transmitted over landlines to the launch complex blockhouse and the Range Control Center, and is available to Range Users.



INTERCEPT GROUND OPTICAL RECORDER

TECHNICAL CHARACTERISTICS

Camera	BX-7 TV, 70-mm Photosonics or 35-mm Mitchell
Frame rates	10, 15, 30, 45 or 60 f/s (70-mm); 80 to 96 f/s (35-mm)
Aperture	18 in
Magazine capacity	40 or 1,000 ft
Tracking rate	10°/s maximum
Angle limits	Continuous azimuth, -3½ to +92° elevation (tower) 190° azimuth, -3½ to +92° elevation (mobile)
Sighting telescope magnification	20 or 35

A fixed IGOR in an astrodome is located on a tower at Patrick AFB. Three mobile units (called Mobile IGOR Tracking Telescope System, MITTS) are available. These may be towed to operating sites or transported by C-124 aircraft.

2.3.2.5 RML/Itek 48-Inch Telescope (Meteor II)

The RML/Itek telescope is equipped with an f/2.5 solid CerVit paraboloidal primary mirror. A 5-element Wynne type corrector gives a 35-mm diameter coma-free flat field at the f/2.5 prime focus. This focal position can be used with a 35-mm camera specially modified to use high resolution thin base film. A set of reimaging lenses, supported on an additional spider, can be added in train with the prime focus to give an f/5.0 35-mm format film plane. A second attachable support spider holds a 40-mm SIT TV camera which permits a full field of view format at the f/2.5 focal plane. The limiting brightness equivalent value for this system, when operated in a cine mode, is 16th to 17th magnitude. Provisions are incorporated in both the f/2.5 and f/5.0 systems for the use of narrow bandpass filters.

A remotely controlled reflex mirror can be rotated into position to direct the optical axis through a periscope-relay lens system to a right-angle cube on top of the telescope which directs the optical axis back parallel to the primary mirror axis. The relay lens system is designed so that the incoming light is brought to focus at an equivalent f/10 plane.

On the telescope top surface is mounted a table which can be positioned at various points along the f/10 optical axis with a servo torque-motor-driven lead screw. An attached digital encoder provides a readout of table position with a precision which ensures table positioning to a least count smaller than the depth-of-focus tolerance of f/10. During mission operation the table is continuously positioned as a function of range to target by the computer to maintain accurate focus.

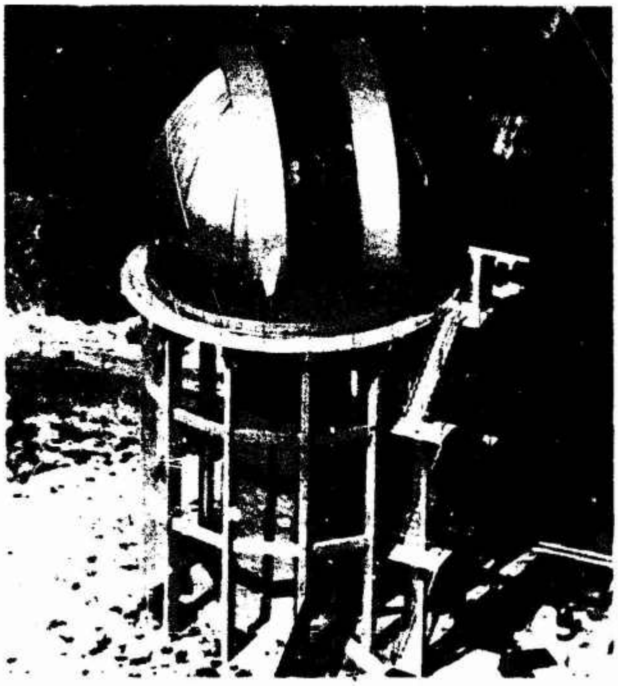
The translating table carries a reimaging lens with provisions for varying the back conjugate distance to adjust from f/10 to f/15. A double, 5-position filter wheel contains both long wave, sharp-cut spectral filters and a graded series of neutral density filters for contrast and exposure control.

Video imaging cameras mounted on this table can be either standard or infrared vidicon cameras, S-25 photo surface image-orthicon camera, or extended red S-20, 25-mm or 40-mm SIT cameras. The orthicon cameras and the 40-mm SIT cameras have various options of scan and of field rates.

The telescope is carried on an elevation-over-azimuth mount equipped with torque motors and 21-bit shaft angle encoders. A TV boresight telescope provides for star calibration of mount characteristics. The mount can be driven to keep the telescope pointed at a moving space target to within 1 to 2 arc seconds.

In addition to the imagery, insertion can be made on each TV frame of the last digit of the year, day of year, time of day to 1/10 second, effective focal length, azimuth to 1/10 degree, elevation to 1/10 degree, range, and offset of the f/10 focal plane from infinity. The data is updated 10 times a second.

The telescope is housed in a 36-ft diameter aluminum dome and is supported on a 42-ft tower. The mount is on a central pier which is isolated from the rest of the structure supporting the two floors and the rotating dome. The dome is air-conditioned to control humidity.



ITEK 48-IN TELESCOPE

TECHNICAL CHARACTERISTICS

Sensors	35-mm film cameras at f/2.5, f/5, and f/10. Deep space photometer at f/2.5. Deep space 40-mm SIT camera at f/2.5. Bendix BX-8 image orthicon and 25-mm and 40-mm SIT TV cameras at f/10 to f/150. Standard format visible and near infrared vidicons at f/10 to f/40. (See table 2-31 for film cameras available for use with the telescope.)
Focal lengths . . .	120, 240, 480, continuously variable up to 7,000 in
Aperture	48 in
Tracking rates . . .	Limited to 15°/s for telescope safety.
Angle limits	720° rotation in azimuth; -10 to 190° in elevation
Mount drive	Remote from computer using on-axis tracking Manual, using on-mount joystick

The Itek camera is located at the ETR Malabar site, approximately 20 miles south-southwest of Patrick AFB at 28.0246° north latitude and 279.3144° east longitude.

2.3.2.6 Engineering Sequential and Documentary Photograph Cameras

A summary of cameras for general range use is provided below. Cameras for the ETR Range Measurement Laboratory (RML) Itek 48-in telescope are listed in table 2-31.

There are over two hundred 16-mm, 35-mm, and 70-mm motion picture cameras in the ETR inventory. They are used to support DOD and NASA launch and nonlaunch engineering and documentary photo requirements. They can operate over a wide range of frame and shutter rates using internal and external magazine loads from 100 to 2,000 ft and varied combinations of le[illegible] and accessories to meet a broad range of requirements.

The 16-mm inventory is composed of over 200 Mitchell, Milliken, Fastax, Arriflex, Auricon, Cine Special, Filmo, and Hycam cameras capable of operation at frame rates from 12 f/s to approximately 4,000 f/s using lenses of 5 mm to 180-in focal length in support of launch and nonlaunch engineering and documentary photography.

There are over 80 Flight Research, Photosonics, Mitchell, Fastax, and Arriflex cameras in the 35-mm inventory. These cameras can operate at frame rates from below 10 f/s to over 1,800 f/s using lenses of 50 mm to 240-in focal length. They are used primarily in support of launch engineering and documentary photography.

The combined inventory consists of 44 Hulcher, Mitchell, and Photosonic cameras operable at frame rates of 10 to 60 f/s with lenses of nominal length/aperture to the 500 inches of the ROTI and IGOR tracking telescopes. These cameras are used where a format larger than 35 mm is required and most frequently are used on tracking mounts such as IFLOT, MOTS, ROTI, and IGOR to record missile flight performance and intermediate staging events.

There are over 160 still cameras in the ETR inventory. These cameras range in format size from 35 mm to 8x10 in. With a wide range of lenses and

TABLE 2-31.

FILM CAMERAS FOR RML/ITEK 48-INCH TELESCOPE

Camera	Format	Focal Position	Mode	Rate	Film Capacity	Timing Provisions	Exposure Control
Flight Research Model 207 (Note 1)	22 mm diameter	f/2.5 and f/5	Pulse	4/s	200 to 1000 ft	Alphanumeric on frame to milliseconds	Fixed shutter, Filters, spectral and ND
Pentax (Note 2)	24 x 36 mm	f/10	Manual	NA	36 exp.	None	Variable Shutter
Mitchell Reflex Sound Recording (Note 3)	16 mm	f/10	Cine	24/s	400-ft and 100-ft magazines	On Magnetic Strip	Fixed shutter, filters
Pentax	24 x 36 mm	f/2.5 and f/5	Pulse			None	Variable Shutter

NOTES
SYNCHRONIZING PROVISIONS

1. Pickup on shutter, timed from computer clock.
2. None
3. None-data inform. on video from vidicon camera used at reflex viewing position.

accessories they are used in fixed positions or hand-held to support launch and nonlaunch photo requirements.

2.3.3 Laser Illumination

A laser illumination facility is operated by the ETR at the Range Measurements Laboratory complex at Malabar, Florida. One transmitter system (Meteor I) is available which provides target illumination for photography coverage by the RML/Itek 48-in tracking telescope (see paragraph 2.3.2.5).

The Meteor I transmitter telescope is mounted on a modified Nike-Ajax pedestal. The laser beam is reflected upward through the azimuth axis of the mount and horizontally into a 20-in aperture lens assembly. Beam divergence is variable from 0.12 mrad to 17 mrad; the laser firing rate is nominally 30 per minute. It is triggered locally by the XDS Sigma 7 computer.

A 120-inch focal length Questar/TV boresight system is coaligned with the transmitter telescope, the azimuth and elevation axes being equipped with 20-bit digital encoders to provide angular output data.

2.3.4 Opto-Radiometric

Opto-radiometric equipment is used by the ETR to determine certain electromagnetic radiation characteristics of missile flights and to measure atmospheric attenuation. The radiation measurements can be divided into three categories: (1) radiometric, total energy in a relative wide spectral interval, (2) spectral total energy in a very narrow spectral interval, and (3) spatial, radiometric, or spectral energy as a function of position within the field of view. Additionally, dimensional and shape data become important when resolved images are present.

Some typical types of opto-radiometric data provided are as follows:

- Effective fireball, nosecone, and decoy temperature
- Energy distribution of an explosive fireball
- Radiant intensity
- Spectral emission
- Ablation rates
- Thermal buildup and decay rates
- Absolute spectral transmission of the Earth's atmosphere

The most extensive ETR opto-radiometric capabilities exist on the two Advanced Range Instrumentation Ships (ARIS): USNS Arnold and USNS Vandenberg. Four subsystems exist on each ARIS for obtaining opto-radiometric data. These are boresight cameras installed on radar and telemetry tracking antenna mounts, an instrumented IFLOT (see paragraph 2.3.2.1), the ballistic cameras array (see paragraph 2.3.1.2) of four fixed cameras, and the Precision Optical Pedestal System (POPS). Photographic instruments installed in these subsystems provide a means of acquiring optical signature data in the 0.28 to 0.9-micron spectral region. Except for the fixed wide-field ballistic plate cameras, ARIS optical instruments are used in a tracking mode and record optical images.

The USNS Redstone is equipped with two ballistic plate cameras and an IFLOT instrumented with four motion picture cameras for obtaining spectral diagnostic, temperature, and scintillation data during reentry.

Signature data is also obtained at Ascension with two Fairchild T-11 aerial mapping cameras and an IFLOT tracker with six motion picture cameras. The Ascension installation also includes six BC-4 ballistic camera systems.

2.3.4.1 ARIS (USNS Arnold & USNS Vandenberg)

Boresight cameras installed on the radar and telemetry tracking antenna mounts provide primary sources of radiometric data. These are standard 35-mm Mitchell cameras with Zoomar f/8 40-in focal length lenses. Table 2-32 lists the frame rate, exposure time, emulsion, filter, and spectral response typical for day or night operation.

The ARIS IFLOT is a one-man, manual tracking mount located in front of the star tracker. Target acquisition is accomplished with an open gunsight and the visual null indicator. The IFLOT also provides two-speed synchro designate data to the ship acquisition system.

IFLOT instrumentation and associated optical parameters are given in table 2-32. These instruments include high resolution spatial, surveillance, ultraviolet (UV) cinespectrograph, and infrared (IR) cinespectrograph cameras.

Ballistic camera arrays on the ARIS are discussed in paragraph 2.3.1.2. Their optical parameters are included in table 2-32 for convenience. One set of instruments, presently on the USNS Arnold, consists of four BC-4 cameras with 12-in Aero Ektar lenses. The second set of instruments, now on the USNS Vandenberg, consists of four K-19 cameras with 300-mm Aero Ektar lenses. Each array consists of two ballistic cameras and two ballistic spectrographs.

The POPS provides ARIS with reentry data capacity for cold body image photography, daylight cinespectrograph measurements, and high-speed radiometry measurements.

A modified Nike mount is used to support the optical sensors. It is suitable for supporting approximately 1,000 pounds of equipment and has the capability of accurate designation/slaving to the shipboard tracking radars or computers. The slaved optics instrumentation is located amidships on the bridge deck. The POPS mount can be slaved to either of the primary radar tracking systems. The slaved optics system has the following features:

Above decks:

- Parabam astrodome, 12-ft diameter
- Nike pedestal, modified bearings and servo drive
- 180-in, f/10 Perkin-Elmer Lens, 70-mm Photosonics 10A camera
- Cinespectrograph Barnes 18-138, with 150-in, f/10 lens
- Pair of cineradiometers. Photosonics 1P, 20-in, f/5 lens
- Surveillance camera Mitchell 35-mm, 90-f/s with 10-in f/5.6 Schneider Symmar lens
- TV monitor/alignment camera with a 40-in Telestar lens

Below decks:

- Operations control console, dual rack
- Camera control units/test and calibration control
- Data handling rack for ships computer interface
- Interconnecting cabling
- Miratel TV Monitor, TV17R

TABLE 2-32. OPTICAL INSTRUMENTATION PARAMETERS

INSTRUMENT (CAMERA TYPE)	LENS	FOCAL LENGTH (IN)	F/NO	FIELD OF VIEW (°V X °H)	FRAME RATE F/S	EXPOSURE TIME (S)	EMULSION	FILTER	WAVELENGTH RESPONSE (μ)
BORESIGHT CAMERAS (3)									
IIR-C BORESIGHT (35MM MITCHELL)	ZOOMAR	40	8	1.0 X 1.6	30	1/720 (DAY) 1/90 (NIGHT)	LSB 2475	15G 1A	0.5 – 0.7 0.4 – 0.7
IIR-L BORESIGHT (35MM MITCHELL)	ZOOMAR	40	8	1.0 X 1.6	30	1/180 (DAY) 1/90 (NIGHT)	HSIR	15G	0.5 – 0.9
TELEMETRY BORESIGHT (35MM MITCHELL)	ZOOMAR	40	8	1.0 X 1.6	30	1/360 (DAY) 1/90 (NIGHT)	EF	1A	0.4 – 0.7
IFLOT (5 CAMERAS)									
SURVEILLANCE	SUMMAREX	3.5	DAY 4.0 NIGHT 1.5			1/720 1/190	HSIR HSIR	15 15	0.53 – 0.9 0.53 – 0.9
(35MM MITCHELL) (TWO EACH)	SUMMAREX	3.5	DAY 4.0 NIGHT 1.5	12.5 X 16.7	90	1/720 1/190	PLUS-X 2475	1A,15 or 25 NONE	0.4 – 0.65 0.4 – 0.7
HIGH SPATIAL RESOLUTION (70MM PHOTOSONICS)	GOERZ	120	10	1.1 X 1.1	45	1/540	4-X (DAY) 2475 (NIGHT)	15G 1A	0.5 – 0.7 0.4 – 0.7
	JONEL	80	8	1.6 X 1.6	45	1/540 (DAY) 1/180 (NIGHT)	4-X 2475	15G 1A	0.5 – 0.7 0.4 – 0.7
UV CINESPECTROGRAPH (70MM BARNES 18-134) (NOTE 1)	MAKSUTOV	12	2.7	5.3 X 10.7	30	1/90	103-0	NONE	0.28 – 0.52
IR CINESPECTROGRAPH (*70MM BARNES 18-134) OR	MAKSUTOV	12	2.7	5.3 X 10.	30	1/90	HSIR	GG-7	0.45 – 0.9
(**70MM PHOTOSONIC 10AL) (NOTE 2)	AERO- EKTAR	12	2.5	10.7 X 10.7	30	1/90	HSIR	4	0.45 – 0.9
FIXED CAMERA ARRAY (4)									
*FAIRCHILD K-19B	AERO- EKTAR	12	4 TO 16	36 X 33	NA	NA	1-N 103-F	4 NONE	0.5 – 0.9 0.38
**WILD BC-4 (NOTE 3)	AERO- EKTAR	12	2.6	33 X 33	NA	NA	1-N 103-F	NONE	0.5 – 0.9 0.38 – 0.6

NOTES.
SPECTRAL RESOLUTION
1. 2Å
2. 10Å (APPROX), 3-5Å
3. 5-10Å

* VANDENBERG INSTRUMENT ONLY
** ARNOLD INSTRUMENT ONLY

The primary optical system is a high resolution cinetelescope with a focal length of 180 in and f/10 aperture. Automatic exposure and focus controls operate in conjunction with a modified 70-mm Photosonics 10A camera. This optical equipment is mounted on an upgraded Nike pedestal. Pedestal slaving precision is estimated between 10 and 20 seconds of arc. Dynamic angular performance has been demonstrated in elevation at 910 mrad/s, 1200 mrad/s/s; azimuth 910 mrad/s, 1100 mrad/s/s. It is estimated that cold body image photography at sea may be possible with one and one-half seconds of arc resolution.

High-resolution spectrographic measurements are made with a Barnes 18-138 Czerny-Turner Cine-spectrograph. The lens for this system is a 150-in, f/10. Spectral response is 0.39 to 0.62 micron. This instrument is capable of daylight cinespectroscopy.

The cineradiometers operate at 100 f/s. One camera covers the IR spectrum of 0.5 to 0.9 micron. The second covers the visible spectrum from 0.4 to 0.7 micron. Reentry object tumble, scintillation, ablation, and materials identification are aided by analysis of these data.

2.3.4.2 RIS (USNS Redstone)

The USNS Redstone ballistic cameras are Wild BC-4 (see paragraph 2.3.1.2) cameras with rotating disc-type shutters. The cameras are mounted in yoke-type pedestals which permit positioning the camera in azimuth and elevation. They are positioned side by side to optimize data coverage. One camera, configured with a 300 line/mm transmission grating, is operated in an open shutter mode, and the second in a shutter-time-chopped mode.

The IFLOT tracking mount on the Redstone is configured with four motion picture cameras: one 70-mm Photosonics camera with a 20-in lens and a 150-line/mm transmission grating, two 35-mm Mitchell cameras with a 50-mm lens for engineering sequential data, and one 35-mm Mitchell camera with a 75-mm lens and a 300-line/mm transmission grating.

2.3.4.3 Ascension Island

Signature data is obtained at Ascension with two Fairchild T-11 aerial mapping cameras and an IFLOT tracker with six motion picture cameras.

The T-11 aerial mapping camera has a 6-in Metrogen lens, between-the-lens type shutter, and interchangeable film magazines. It accepts film 9-½ in wide and up to 390 ft long.

The IFLOT tracking mount (see paragraph 2.3.2.1) is configured with six motion picture cameras: two 35-mm Mitchell cameras with bandpass filters for temperature and scintillation data, one 35-mm Mitchell camera with 150 line/mm transmission grating for spectral data, one 35-mm Mitchell camera for engineering sequential data, one 70-mm Photosonics camera with 300-line/mm transmission grating for spectral data, and one 70-mm Photosonic camera for engineering sequential data.

Ballistic cameras at Ascension are discussed in paragraph 2.3.1.2.

2.4 IMPACT LOCATION SYSTEMS

Impact location systems are underwater sound detection systems used to obtain the geographic position of reentry vehicles or other missileborne objects upon impact into the sea. Systems operated on or by the ETR can be grouped in two basic types as a function of the technique used for data retrieval.

The first basic type is the ETR Missile Impact Location System (MILS) which uses a cable to relay sound signals detected by underwater hydrophones to a nearby land station where the signals are recorded. The system is based on: (1) the production of sound generated by impact of an object(s) on the surface of the water, or by the underwater explosion of a bomb carried by a missile component, and (2) the detection of the sound and recording of its arrival time at a number of known hydrophone locations in the ocean. The location of the impact or bomb detonation point can be computed from a knowledge of the hydrophone positions, the velocity of propagation of sound in the ocean, and the arrival times of sound at the hydrophones.

The second type is the Sonobuoy Missile Impact Location System (SMILS) which retrieves its data in real-time by attendant aircraft via a radio link. This system consists of an ocean bottom acoustic transponder array plus an array of expendable surface hydrophones (sonobuoy) deployed for each test mission. Specially equipped aircraft sow the sonobuoy and receive/record impact data relayed from the sonobuoys. The transponder array in the impact area provides a geodetic reference.

2.4.1 Missile Impact Location System

The MILS used on the ETR consists of two types: the target array (also called pentagon or splash array) and the sofar (sound fixing and ranging) system (also called the broad ocean area (BOA) system). The target array provides high accuracy information in a limited target area, usually within a 10-nmi radius. The hydrophones are placed on the bottom in essentially a regular pentagon formation with a sixth hydrophone at the center, the target area being the water surface above the pentagon. The sound transient produced at the surface by an impacting reentry vehicle travels through the water to the hydrophones. The computation for impact location is the conventional space hyperbolic solution in which the z term (altitude) is a constant equivalent to the depth of the water. The pentagon configuration ensures that for any point of impact within the target area, there will be at least four hydrophones with ranges less than the refraction limit so they will receive signals by a direct transmission path.

The BOA configuration is essentially a plane hyperbolic system taking advantage of the long range sound transmission in water (about 2,000 nmi) and the superior identification characteristics of the sofar channel. An inversion point (the sofar axis), or minimum velocity of sound, is formed at a depth of 3,000 to 4,000 ft by decreasing temperature and increasing pressure. At the depth of minimum velocity, attenuation of sound energy with distance is nearly linear rather than proportional to the square of the distance, and even comparatively low level sounds can be detected at great distances. The BOA hydrophones are placed as close as possible to the sofar axis. A sofar bomb with pressure-activated control is mounted in the reentry body and allowed to sink with it until the bomb detonates near the sofar channel.

The accuracy of the system depends on the geometrical relationship of the impact position to the hydrophone positions, signal timing, and on the velocity of sound propagation. There are many sound paths between the explosion point and the hydrophone positions, resulting in many sound arrivals at any one hydrophone from a single explosion. However, the sound path along the sofar axis, traveling in the plane of the system and at the lowest velocity, is the last arrival to a hydrophone and can be identified. Its time of arrival together with hydrophone position and values of "horizontal velocity" (measured by calibration) are the inputs for computing the impact location. Data from at least three hydrophones is needed for a solution.

The geodetic accuracy of the BOA has been improved at specific midrange impact areas by calibration (measurement of acoustic propagation velocity) near the time of the missile test. The calibration consists of a ship releasing a few sofar bombs while the ship's location is being determined by the Acoustic Ship Positioning System (ASPS). Three or four transponders, placed in each impact area, are interrogated by a pulse from the ship, and reply at individual frequencies. The

geodetic position of the transponders is surveyed by the most accurate method available, e.g., BRN-3 or SRN-9 navigation systems.

Impact location (geodetic and relative) of multiple reentry vehicles is provided in the BOA by varying the amount of explosive carried in the sofar bomb. An approximate 5 dB difference in the peak signal level is observed when the charge weight is doubled. For instance, the charge weights recommended for midrange areas are 1, 2, and 4 pounds for three reentry vehicles.

2.4.1.1 Location

Figure 2-7 shows the general location of the active ETR MILS/MILS sites. Precise coordinates are presented in the *AFETR Geodetic Coordinates Manual.*

Target Arrays (hydrophones positioned on bottom)

Grand Turk	(85 miles northeast of, at a depth of 3 miles, 24-nmi diameter)
Antigua	(150 nmi northeast of, at a depth of 3 miles, 5-nmi diameter)
Ascension	(20 miles west-southwest of, at a depth of 2 miles, 12-nmi diameter)

BOA Arrays (BOA hydrophones positioned at or near the sofar axis)

Barbados

Bermuda

Eleuthera

Antigua

Grand Turk

Puerto Rico

Ascension

Cape Hatteras

SMILS Arrays (The acoustic ship positioning transponders located on the bottom)

Bottom Array	Distance Downrange (nmi)
C2A	550
C9C	1,900
C11A	2,500
C12	3,000
C15W	1,500
C15E	1,550
C16	4,700

2.4.1.2 Accuracy

Accuracies of the MILS systems are classified Confidential. They may be obtained from AFETR/Systems Analysis Office.

2.4.1.3 Data Handling

The hydrophone outputs of the arrays are recorded simultaneously on strip charts with timing annotation and on magnetic tape with timing and operator voice annotation. The strip chart and magnetic tape recordings are then forwarded to Patrick AFB for postlaunch data processing.

Arrival times are obtained manually at each site from the strip chart recordings, and quick-look information from all sites can be relayed by way of radio or telephone to the mainland for immediate use. Recorded signals collected from arrays at Grand Turk and Antigua are transmitted from those stations to the mainland by way of undersea cable circuits, and signals from the array at Ascension are transmitted by hf radio circuits to permit rapid delivery of results to Range Users.

2.4.2 Sonobuoy Impact Location System

The SMILS (Sonobuoy Missile Impact Location System), used to determine the impact location of missile reentry bodies, consists of four basic elements: (1) an ocean bottom acoustic transponder array, (2) specially equipped P-3 Orion aircraft, (3) modified Navy ASW sonobuoys, and (4) an ocean surface duct.

The transponder arrays in the impact area consist of 10 deep ocean transponders which serve as a geodetic reference point for the sonobuoys. These

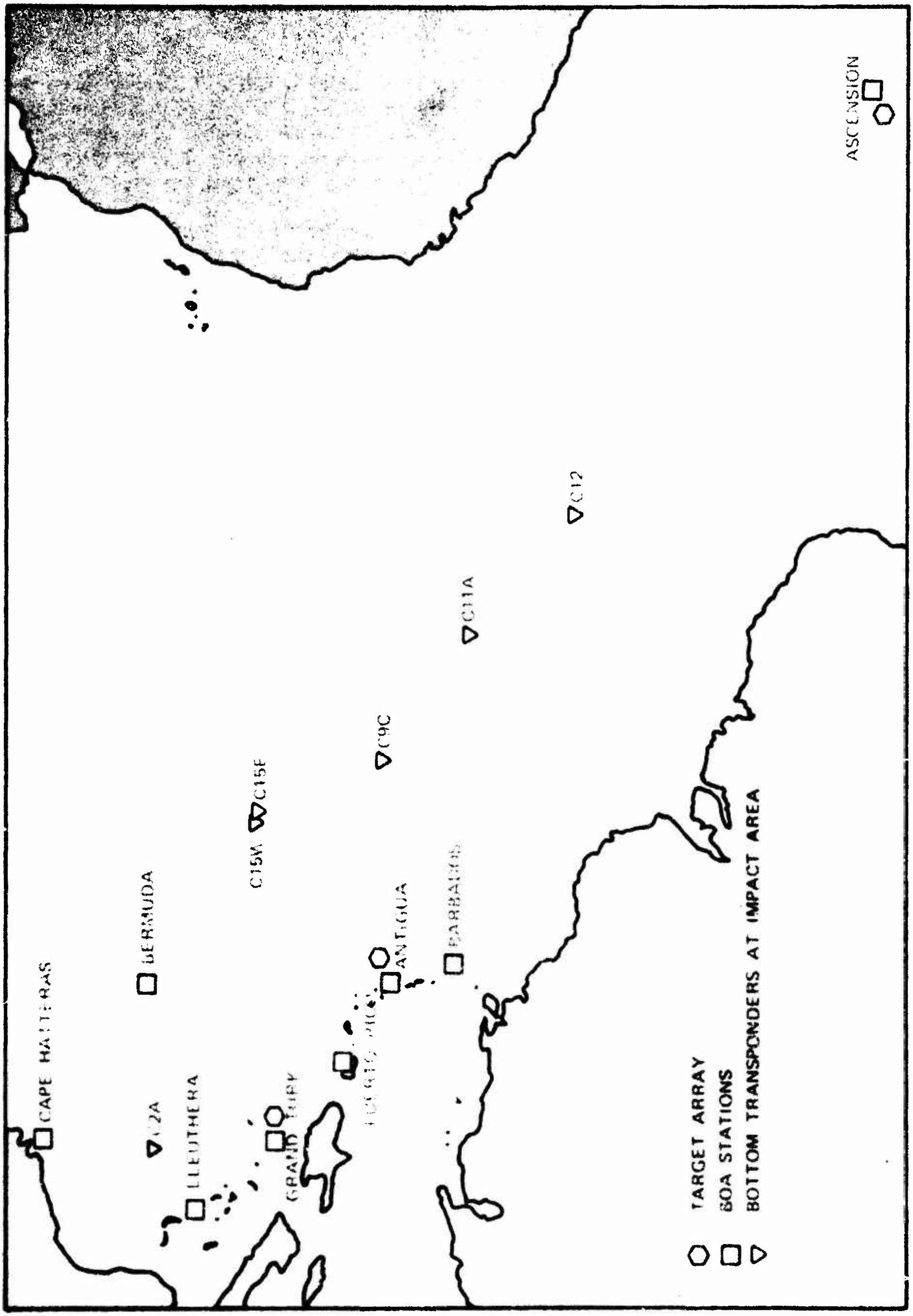


Figure 2-7. Impact Location

transponders are energized by a 16-kHz interrogator signal and respond each on a different frequency at ½-kHz intervals from 7.5 to 12 kHz. Each transponder array is located geodetically by the Navy Satellite System.

Two Navy P-3 Orion Lockheed Electra ASW (antisubmarine warfare) aircraft assigned to Air Test and Evaluation Squadron One (VX-1), Pautuxet River NAS, Md, have been modified to accommodate the SMILS. These modifications provide: (1) the capability to receive and record additional sonobuoys (24 and 32, respectively), (2) a timing system, and (3) a monitoring and quick-look recording capability.

The modified ASW sonobuoy is an expendable item designed to be dropped from an aircraft into the sea where it detects underwater sounds, and by means of a self-contained transmitter relays this information to the aircraft. There are 31 transmitter frequency channels between 162.25 kHz to 173.50 kHz. The sonobuoys have been modified to increase the active life by installing additional batteries, and the circuitry has been changed to increase the frequency response in order to receive the ASPS transponders interrogator and reply signals. In addition, some of the sonobuoys have been modified to incorporate a low frequency (2.5 kHz) pinger. An interrogator sonobuoy is deployed by a ship or aircraft in the center of the transponder array. This device is essentially an AN/SSQ-41 sonobuoy modified to transmit a 16-kHz signal, and to receive the 7.5 to 12-kHz transponder response signal.

The wind-mixed surface layer of the ocean creates an isothermal duct or waveguide through which sound reliably propagates for many miles. Splash signals have been received through this surface duct at ranges up to 20 miles. The depth of the ocean duct is determined by means of a bathythermograph sonobuoy dropped from the SMILS aircraft. The depth together with the planned reentry body impact footprint are used to determine the sonobuoy pattern to be employed.

A typical sonobuoy pattern for a single aim-point footprint consists of four rings about 3 nmi apart with a total outside diameter of about 20 nmi. Thirty sonobuoys including an interrogator sonobuoy are deployed during each mission.

The transponders which are energized by the 16-kHz interrogator signals serve to locate the 2.5-kHz pinger sonobuoys relative to the transponders. The signals from these pinger sonobuoys propagate through the surface duct and are received by the sonobuoys. The splash position relative to the sonobuoys as well as the time at which splash occurred can then be determined.

2.4.2.1 Location

SMILS is presently used exclusively to support the fleet ballistic missile programs. Impact area coordinates are classified. Descriptions and locations are available from AFETR/Systems Analysis Office.

2.4.2.2 Accuracy

Accuracies of the SMILS system are classified. They may be obtained from the Navy Strategic Systems Project Office (SSPO), Washington, D.C.

2.4.2.3 Operations

The USNS Strategic Systems Project Office (SSPO) is responsible for the overall operation and funding of SMILS. The Navy provides the P-3 aircraft support and various other services (through the Palisades Geophysical Institute, Bermuda) such as sonobuoy acquisition/modification, mission planning/support, and data analysis/reduction.

The AFETR provides the transponder arrays (by acquisition, installation, and survey of transponders) on a reimbursable basis.

2.5 METEOROLOGY

An integrated meteorological system is used to obtain surface and upper-air weather data at several points along the Range in support of Range Users. Satellite data is also received and interpreted in real-time from most meteorological satellites passing over the Range. The following functions are performed by the ETR Meteorological Section:

1. Meteorological data is collected with standard meteorological equipment whenever possible at the following locations: Cape Canaveral AFS (CCAFS), Patrick AFB, Grand Turk, Antigua, and Ascension. Automatic weather stations are used at Grand Bahama and during the night at Grand Turk.

2. Specialized meteorological and micrometeorological support are provided to the Kennedy Space Center (KSC).

3. Meteorological forecasts are made for all operations at CCAFS, for NASA unmanned programs, and for DOD operations at KSC.

4. Upper atmospheric data is collected by balloon and rocket-borne instruments. Standard rawin soundings are conducted by the Range ships and by CCAFS, Grand Turk, Antigua, and Ascension. Rocketsondes are fired at CCAFS, Antigua, and Ascension.

5. The Weather Information Network Display System (WINDS) at CCAFS and KSC is operated and maintained for the purpose of monitoring and predicting low level diffusion characteristics.

6. Assistance, as required, and coordination with Space Flight Meteorology Group is provided on all meteorological forecasts in support of NASA manned program operations and other joint missions.

7. Weather warnings are provided to CCAFS and KSC.

8. Satellite data received directly by the Cape Canaveral Forecast Facility (CCFF) or that received by a downrange station and relayed real-time to the CCFF is interpreted.

The following paragraphs briefly describe the major equipment items; a more detailed explanation of instrumentation and capabilities can be obtained from AFETRP 105-1, *Weather – Meteorological Handbook.*

2.5.1 Surface Instrumentation

Surface weather observations are taken on a 24-hour basis at CCAFS using standard meteorological observation practices. Instrumentation used for observations is similar to that used at most Air Force bases and includes the following items:

Mecurial Barometer ML-2-H
Barograph ML-3-D
Psychrometer ML-224/24
Hygrothermograph
Wind Measuring Set AN/GMQ-11
Cloud Height Set AN/GMQ-13A
Ceiling Light Projector ML-121

Descriptions and specifications of this equipment may be found in *Air Weather Service Publication (AWSP) 105-3.* The more specialized surface equipment is described in the following paragraphs.

2.5.1.1 AN/FPS-77 Storm Detection Meteorological Radar Set

The AN/FPS-77 radar, located at CCAFS, provides displays of the horizontal and vertical cross-sections and intensity measurements of precipitation areas within a 120-nmi radius. Antenna controls permit continuous scan, manual positioning, and elevation sector scan capability.

Radar scope photography is available using either of two methods. Polaroid pictures may be taken of any of the regular console scopes. The second system incorporates a 35-mm recording camera mounted on a remote PPI radarscope which includes a video integrator and processor for contoured intensity presentations. Photos are taken automatically with this system, providing a sequence of radar scope presentations and an excellent data base for analysis of weather situations.

The radar detectable data from the FPS-77 is digitized and processed by a CDC 3100 computer

(Digitized Automatic Radar Tracking System, DARTS) producing an analyzed teletype printout for storm track following and prediction extrapolation throughout the entire 200-nmi range of the radar. This system greatly aids the weather warning function by decreasing the impact warning circle of storms and work centers from 5 miles to 3 miles, thereby reducing the downtime on gantries due to severe storm activity.

2.5.1.2 Launch Pad Lightning Warning System (LPLWS)

The Launch Pad Lightning Warning System (LPLWS) provides the duty forecaster at CCFF the capability of detecting and monitoring lightning from eight locations – seven major launch complexes and the Port Canaveral Navy complex. The system consists of eight electrostatic field sensors or mills, a CDC (Control Data Corporation) 3100 computer for data acquisition and analysis, and a teletype to print out for the forecaster, an analysis of lightning potential and lightning occurrence. Each field mill's output is continuously recorded by strip chart recorders and simultaneously analyzed by the computer. The computer translates the field strength data into meteorological terms for the forecaster and provides the following information for each of the eight sites:

1. Knowledge of highly charged clouds where lightning is eminent.

2. When thunder can be heard by an observer (approximately 4 miles to 10 miles from a site).

3. When lightning is occurring at a site (within 3 miles).

4. The intensity of an electrical storm occurring at a site.

2.5.1.3 Weather Information Network Display System (WINDS).

The WIND System consists of: (1) 16 stationary towers that range in height from 54 to 500 ft, (2) wind, temperature, and dew point sensors attached to the towers at various heights, (3) a CDC 3100 computer that receives and processes the sensor measurements, and (4) a 4-terminal teletype circuit that prints out the processed data. The towers are located throughout Cape Canaveral and Merritt Island. The displayed data, available in 30, 15, or 5-minute readouts, consist of numerical values for the variables: wind direction and speed, wind gusts, temperature, dew point, lapse rate (i.e., "Delta T" – temperature change with height), two distances for toxic concentrations (one for concentrations of 25 parts of toxic per one million parts of air and another for 5 parts of toxic per one million parts of air), and standard deviations of the wind direction.

2.5.2 Upper Air Instrumentation

2.5.2.1 AN/GMD-4 (Rawin Set)

The AN/GMD-4 rawin set is a 1680-MHz radio direction finder used for automatic tracking of a balloon or rocket-borne instrumentation package. During tracking, the transmitter generates a 400 to 406-MHz cw carrier modulated at 81.94 kHz. This is a ranging signal which is transmitted to the radiosonde set. A pulsed 1680-MHz signal carrying the 81.94-kHz fm modulation is returned by the radiosonde set and sent to the receiving system. This system demodulates the rf signal to separate position data, range data, and meteorological data. The position data are sent to the antenna positioning system for precise antenna control and for data relay to a recorder. The range data (ranging subcarrier) are send to the ranging system for measurement of slant range. The pulsed meteorological data are sent from the receiving system to the data processor. Instrument slant range, altitude, and elevation and azimuth angles versus time are recorded on punched tape at sampling rates of 1, 2, 5, or 10 times a minute. Temperature and humidity versus time are presented sequentially in graphic form on the radiosonde recorder AN/TMQ-5 and also punched on paper tape with the instrument position data.

The AN/AMQ-9 radiosonde is a balloon-borne transponder type, designed for use with the AN/GMD-4 ground equipment, which uses a clock-driven commutator to switch between reference frequency, humidity data, and temperature data.

The meteorological data processor automatically provides digital meteorological and position data on punched paper tape. These data represent:

1. Azimuth and elevation tracking angles, and slant range from the AN/GMD-4 to

the balloon- or rocket-borne radiosonde set.

2. Temperature and humidity data being transmitted from the radiosonde corrected for reference frequency drive.

3. Elapsed time.

Station identification, prelaunch calibration data, etc., may be entered manually. The data, acquired in real-time, are presented on teletype coded, punched paper tape.

2.5.2.2 Omega NAVAID Sounding System

The Omega NAVAID sounding system, Buekers Models WO-2 and WO-2Ds, is installed aboard the USNS Redstone and USNS Arnold. This rawinsonde sounding system may be employed on land or sea and does not require a tracking antenna or stabilized platform for the determination of upper air winds. Using a standard 403-MHz fm meteorological radiosonde modified for the retransmission of track information, it accurately determines wind speeds to 1 to 2 meters per record. System accuracy is independent of the distance from the balloon launch site and is constant over the entire flight period. Thermodynamic data are acquired using conventional radiosonde observation techniques. This equipment is scheduled to be installed on the USNS Vandenberg in FY-76 and on Grand Turk in FY-77.

2.5.2.3 High Resolution Wind Measurement Balloon (Jimsphere)

These measurements are obtained by use of a rigid radar reflective balloon tracked by a Range radar. In contrast to standard sounding balloons, this balloon is aerodynamically stable and retains a constant volume. Wind speed, direction, and shear from the surface to 60,000 ft are computed from the radar tracking data.

2.5.2.4 LOKI Meteorological Rocket System

The solid propellant LOKI rocket lifts an 8-pound dart assembly to approximately 210,000 ft. The motor burns for 1.9 s (approximately 4,000 ft) at which time the dart and motor separate and the dart coasts to apogee. The launcher consists of a rail assembly mounted on a pedestal.

The dartsonde is carried aloft by the LOKI rocket. After separation from the rocket, it coasts to a 210,000-ft apogee, at which time the ½-pound instrument is deployed and descends on a starute. As the dartsonde descends, temperature measurements are transmitted to a GMD receiver. The starute is tracked by radar to determine wind speed and direction.

2.5.2.5 Super LOKI Meteorological Rocket System

The solid propellant super LOKI rocket is 4 inches in diameter compared to the 3 inch diameter LOKI motor. This higher performance motor enables altitude capabilities up to 300,000 ft depending on the system configuration. There are four separate configurations of the super LOKI:

PWN-10A Transponder
PWN-10A Mod-I Stable Booster Transponder
PWN-11A Stable Booster
PWN-12A Robin

2.5.3 Data Processing

A CDC-3100 data processing system on the ETR provides accurate reduction of upper air meteorological data. Rawinsonde, meteorological rocket, and upper-air wind data are some of the data reduced by the system. A printed copy and a perforated tape are made of the incoming data. The output data provides tabular printout of altitude, pressure, temperature, and other meteorological parameters. Tabular printouts, card output decks, and magnetic tapes are provided to Range Users to evaluate test performance.

2.5.4 Satellite Imagery Acquisition and Processing

Satellite data is received and processed by the CCFF on a daily basis from NOAA (National Oceanic and Atmospheric Administration) and DMSP (Defense Meteorological Satellite Program) satellites. This data provides a wide area, bird's-eye view of the weather patterns and greatly adds to the conventional data where available or provides a sole source of data over isolated locations along the Range. These photos are used as observing, forecasting, and briefing tools by the forecaster to enable the decision-makers to receive the best meteorological information with regard to their program(s). Using the available visible and infrared

satellite imagery some of the parameters that the meteorologist can determine are: cloud cover, type, cloud tops, movement of cloud masses, wind flow at the cloud levels, and sea temperature over clear areas. The tracking systems used at the CCFF are briefly described in the following paragraphs (greater detail is available in the *AFETR Meteorological Handbook*).

2.5.4.1 APT Satellite Tracking Station

Automatic recording of APT (automatic picture transmission) and scanning radiometer and infrared imagery from NOAA satellites are received simultaneously during daylight hours with only infrared data received during the nighttime. The satellites are tracked with a fixed wide beamwidth helical antenna; during test support and normal duty hours, tracking is performed by Range telemetry sites at KSC and at downrange sites when necessary. A global requirement for real-time satellite data is necessary for some tests. This requirement can be satisfied by having NASA telemetry stations in the desired area track the satellite and transmit the data real-time to CCFF through the NASA communication network. Received satellite data is processed by a Muirhead 115B/1 photographic recorder which provides a quality product photograph with accurately calibrated gray scale levels to enhance the clarity and confidence level of cloud luminance and temperature measurements received.

2.5.4.2 Defense Meteorological Satellite Program (DMSP)

DMSP satellites are similar to the NOAA satellites in that both systems are Sun synchronous and polar orbiting. But, the DMSP is a much more versatile system with much greater resolution. Orbiting 450 nmi above the Earth, about half the altitude of the NOAA satellites, the DMSP system provides visual, near infrared, and infrared data every 6 hours over a 1,600 to 1,800 nmi swath below the satellite with a 0.3 nmi resolution along the centerline of the swath. Information may be received and processed using specialized equipment installed in the CCFF for any DMSP pass within the 1,500 nmi acquisition range. The system is more flexible than previous systems, allowing processing variations to bring out or enhance certain cloud or land features; the low light visual imagery capability greatly aids interpretation and gridding accuracy on nighttime passes. The DMSP can provide meteorological data on clouds, weather systems, wind, precipitation, and severe weather. In addition, it has applications in oceanography, geophysics, and Earth resources. An example of a high resolution visual photo is shown in figure 2-8.

Fig. 2-8. High resolution visual DMSP photo showing many of the items that may be interpreted from satellite data.

2.5.5 STAFFMET Library

The detailed information in the STAFFMET library is inclined toward support of AFETR programs and locations; however, much general information is also available covering the complete spectrum of meteorological support in the aerospace environment. The library includes many standard texts and articles related to meteorology. An extensive climatology section includes basic data for most areas of the world with detailed surface and upper-air data for reporting stations along the ETR plus other stations of interest to Range Users. Also included are a variety of computer programs used to perform various calculations and transformations on atmospheric measurements in support of Range Users.

SECTION 3
SUPPORT SYSTEMS

3.1 COMMUNICATIONS

The Air Force Eastern Test Range (AFETR) operates point-to-point, air-to-ground, ship-to-shore, and intrastation communications using undersea cable, uhf, vhf, and hf radio, satellite, microwave, standard and wideband wire distribution, closed-circuit television, and automatic and manual telephones. These systems are used for voice or teletype transmission of operational and administrative traffic, transmission and reception of test data, and for transmission of launch vehicle commands (see table 3-I). Additional details can be obtained from the *AFETR Communications Handbook*.

3.1.1 Interstation Communications

3.1.1.1 Undersea Cable

Coaxial undersea cables have been a most important part of AFETR communications since 1954. The original cable, with land-based repeater amplifiers at 60 to 70-nmi intervals, was installed by Western Electric (WECO) in 1954. The cable presently is serviceable only between Grand Bahama and Eleuthera. The bandwidth (150 kHz) was multiplexed to provide 12 full duplex channels, or if desired, 12 voice channels downrange and 9 voice plus one 45-kHz data channel uprange.

In 1963, the WECO cable between Grand Turk and Ramey AFB, Puerto Rico, was replaced by the Felton & Gixlleume (F&G) cable. At the same time the service was extended to Antigua Air Station. The F&G cable has submerged repeaters at 17.5-nmi intervals with a land repeater station at Ramey AFB. Group modulators and demodulators break the 240-kHz super group into five full duplex 48-kHz groups. A third underwater cable system was placed in service in 1967 by Standard Telephone and Cable (STC). This system links Grand Bahama and Grand Turk with underwater repeaters spaced approximately 29.7 nmi apart. The capacity of this section is also 240 kHz each direction. In order to accommodate the demand for transmission of wideband telemetry data from Grand Bahama to CCAFS, the capacity of the STC cable between these two points was expanded and repeaters spaced 9.7 nmi apart. The capacity of this section of the cable is 1080-kHz, each direction; cable equipment is placed to provide four 240-kHz super groups, two super groups uprange only, and two super groups both uprange and downrange. One of the two-way super groups is instrumented to provide five 48-group channels, three 12-channel 4-kHz full duplex circuits, and two 48-kHz data transmission channels.

One of the uprange 48-kHz data channels, when not needed for data transmission, is used with a downrange 48-kHz channel to establish 12 full duplex voice circuits between CCAFS and Antigua Air Station.

Figure 3-1 shows the existing operating stations and their respective subcable channel and high frequency radio circuit capability.

3.1.1.2 High Frequency Radio (HF)

High frequency, single sideband (HF/SSB) radio is used to span long distances and provide two-way point-to-point, ship-to-shore, and air-to-ground communications. Each radio link is capable of voice, teletype, or digital data transmission.

Point-to-point radio links between major stations primarily use the 45-kW transmitters and antennas. The tri-nested rhombic antennas are cut to specific frequencies and fixed in azimuth. A limited number of 12-MHz frequencies are assigned; however, most hf frequencies are 6 MHz. Two-way point-to-point major rf links are Mainland-Antigua, Mainland-Ascension, Antigua-Ascension, and Ascension-Mahe Island, but other combinations are possible and used when propagation conditions permit.

Additionally hf radio is used on the mainland, Grand Bahama, Eleuthera, Grand Turk, Antigua, Ascension, and Mahe for interisland, ship-to-shore, and air-to-ground communications. The equipment

TABLE 3-1. AFETR COMMUNICATIONS & DATA TRANSMISSION CAPABILITY

	INSIDE PLANT FACILITIES					OUTSIDE PLANT FACILITIES					
	TELEPHONE EXCHANGE (LINES)	MESSAGE CENTER	TECH CONTROL	DIGITAL CRA TIPLEX	VOICE MULTIPLEX	COMMERCIAL CARRIER INTERFACE	CABLE PLANT	MOBILE ESC VANS	SUBCABLE TERMINALS	MOBILE TV VANS	WIDEBAND/VIDEO CABLE
CAPE CANAVERAL AFS	7K	X	X	X	X	X	X	X	X	X	X
GRAND BAHAMA ISLAND	[illegible]	X	X	X		X	X		X		X
ELEUTHERA NAVFAC	[illegible]	X				X	X		X		
GRAND TURK	[illegible]	X	X	X		X	X		X		X
ANTIGUA	[illegible]	X	X	X		X	X		X		X
PUERTO RICO			X			X			X		
ASCENSION	[illegible]	X	X	X		X	X				X
PRETORIA							X				
MAHE		X				X	X				
SHIP (USNS ARNOLD)	[illegible]	X	X	X							X
SHIP (USNS VANDENBERG)	[illegible]	X	X	X							X
SHIP (USNS REDSTONE)	[illegible]	X	X	X							X
SHIP (LCU)											
INSTRUMENTED A/C (ARIA)		X									
PATRICK AFB	5K	X	X	X	[illegible]	X	X			X	X

	SECURE FAC		NAVAID FACILITIES					
	SECURE DATA/TELETYPE	SECURE VOICE	RAPCO'S	CONTROL TOWER	RADAR BEACON	VHF DIRECTION FINDER	TACAN	LORAC NAV SYSTEM
CAPE CANAVERAL AFS	X	[illegible]		X	X			
GRAND BAHAMA ISLAND	X			X	X			X
ELEUTHERA NAVFAC				X	X			X
GRAND TURK	X			X	X	X	X	
ANTIGUA	X							
PUERTO RICO								
ASCENSION	X			X	X		X	
PRETORIA								
MAHE								
SHIP (USNS ARNOLD)	X	X						
SHIP (USNS VANDENBERG)	X	X						
SHIP (USNS REDSTONE)	X							
SHIP (LCU)								X
INSTRUMENTED A/C (ARIA)							X	X
PATRICK AFB	X	X	[illegible]	X			X	

	RADIO FACILITIES: HF			SATELLITE COMM			UHF/VHF				MW	VHF
	AIR-TO-GROUND HF	MOBILE HF CONTINGENCY VAN	SHORE-TO-SHIP COMM	TACSAT TELEMETRY GRD REC TERM	TACTICAL SATELLITE COMM SYSTEM	SATCOM TERMINAL	AIR-TO-GROUND	COMMAND TRANSMITTERS	HARBOR CONTROL RADIO	MARINE RADIOS VHF	MICROWAVE TERMINALS	INTRA-BASE RADIO SYSTEMS
CAPE CANAVERAL AFS	X	X	X	X			X	X	X		X	X
GRAND BAHAMA ISLAND	X		X	X			X	X	X		X	X
ELEUTHERA NAVFAC	X						X		X			X
GRAND TURK	X		X				X		X			X
ANTIGUA	X		X			X	X	X			X	X
PUERTO RICO												
ASCENSION	X		X				X					X
PRETORIA	X											
MAHE	X					X			X	X	X	X
SHIP (USNS ARNOLD)	X		X		X		X					
SHIP (USNS VANDENBERG)	X		X		X		X					
SHIP (USNS REDSTONE)	X		X				X					
SHIP (LCU)	X		X							X		
INSTRUMENTED A/C (ARIA)	X				X		X					
PATRICK AFB							X				X	X

	MANAGEMENT NETS					DATA CAPABILITY			CC TV	
	CORDLESS SWITCHBOARD	POLICE SWITCHBOARD	FIRE REPORTING NETWORK	COMM CONTROL	AUDIO INTERCOM SYSTEMS	DIGITAL DATA TRANSMISSION RATES (KBPS)	ENVIRONMENTAL DETECTION SYS (X V CODE)	WIDEBAND S-BAND TELEMETRY RELAY	CLOSED CIRCUIT TV (MOBILE & FIXED)	TV RECORDING (BLACK & WHITE)
CAPE CANAVERAL AFS	X	X	X	X	X	384	X		X	X
GRAND BAHAMA ISLAND			X	X	X	384				
ELEUTHERA NAVFAC					X					
GRAND TURK				X	X	76.8				
ANTIGUA	X			X	X	76.8	X			
PUERTO RICO										
ASCENSION	X			X	X	2.4	X			
PRETORIA						2.4				
MAHE					X	2.4	X			
SHIP (USNS ARNOLD)				X	X	2.4				
SHIP (USNS VANDENBERG)				X	X	2.4				
SHIP (USNS REDSTONE)				X	X	2.4	X			
SHIP (LCU)					X					
INSTRUMENTED A/C (ARIA)					X	72		X		
PATRICK AFB	X	X	X	X	X		X		X	X

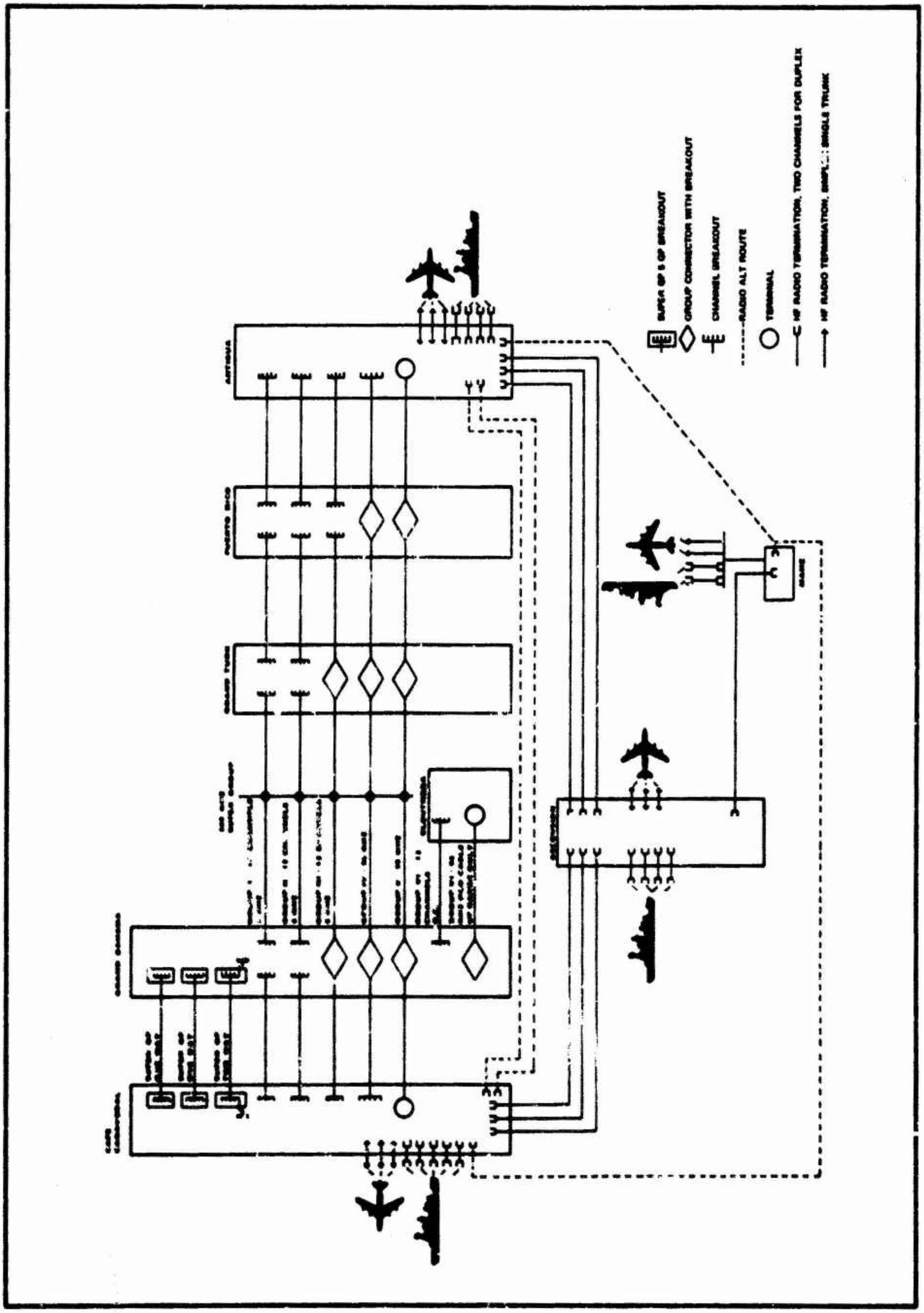


Figure 3-1. ETR Subcable and Hf Radio Configuration

is similar to that used for point-to-point service but used at lower power levels.

The mainland hf transmitter site is located at Malabar, Florida. The site has five 205J-1A Collins 45-kW transmitters for use with rhombic and log periodic antennas; ten 240C-1 Collins 10-kW transmitters for use with rhombic, log periodic, and discone antennas; five 204F-1 Collins 2.5-kW transmitters used with log periodic, discone, doublet, and caged discone antennas; four KWT-6 Collins 500-W transceivers used with log periodic, discone, doublet, caged discone, and whip antennas; and two KWM-2 Collins 100-W transceivers used with whip antennas.

The mainland receiver site, located at CCAFS, has four 5151, sixteen 651F-1, one 50E6, seven 50E6D, and six SX-116 receivers. The receivers are used in combination with the following receiver site antennas: one H log periodic (fixed), one V log periodic (fixed), two 237A1 log periodic (rotatable), three 237B1 log periodic (rotatable), two discone, and two tri-nested rhombics.

Distribution of the remaining hf radio equipment is as follows:

HF TRANSMITTERS

	45 kW	10 kW	2.5 kW	1 kW
Antigua	7	4	3	–
Ascension	13	7	2	–
Mahe	2	6	–	–

	500 W	350 W	100 W
RCC-CCAFS	1	–	1
GBI & Cays	–	2	–
Grand Turk	–	2	–
Antigua	–	–	–
Ascension	–	–	–
Mahe	–	–	–
Eleuthera	–	2	–

HF RECEIVERS

	51S1	50E6	651F1	R390
RCC-CCAFS	–	1	–	–
Antigua	3	10	12	3
Ascension	2	17	20	2
GBI	–	–	–	4
Grand Turk	–	–	–	2
Eleuthera	1	–	–	2
Mahe	2	2	8	–

The mainland hf antenna receiver site is located on CCAFS. There are: 16 Collins 651F1, four Collins 51S1, one Collins 50E6, four Collins 50E6D, three Collins 50E6DF, and six Hallicrafter SX-116 hf receivers. The hf receiver antennas consist of two tri-nested rhombics, five log periodics (fixed and rotatable), and two discone antennas for day and night reception.

The HF/SSB radios on board the aircraft (ARIA/TRAP) consist of three AN/ARC-58 transceivers and use a retractable trailing wire antenna.

The USNS Arnold hf radio complement consists of two Collins 204C-1 10-kW, and two Collins 204F-1 2.5-kW linear amplifiers in combination with four each 310 F-6E exciters using three whip and one long periodic CA-3038 antennas, four ISB 50E7 receivers, one R-390 receiver, one ISB 50E6D receiver, one SP-600 receiver, and five 651F-1URG receivers using six whip antennas.

The USNS Vandenberg hf radio complement consists of two Collins 204C-1 10-kW and two Collins 204F-1 2.5-kW linear amplifiers in combination with four 310F6E exciters using three whips and one log periodic CA-3038 antennas, one R-390 receiver, two 50E7 receivers, six 651F-1URG receivers, and seven whip antennas.

The USNS Redstone hf radio complement consists of six TMC TSTE10K (10-kW hf transmitters), seven TMC DDRR 506 hf receivers, two log periodic antennas, three uhf antennas, six AX-568 hf transmitters, one monopole antenna with four

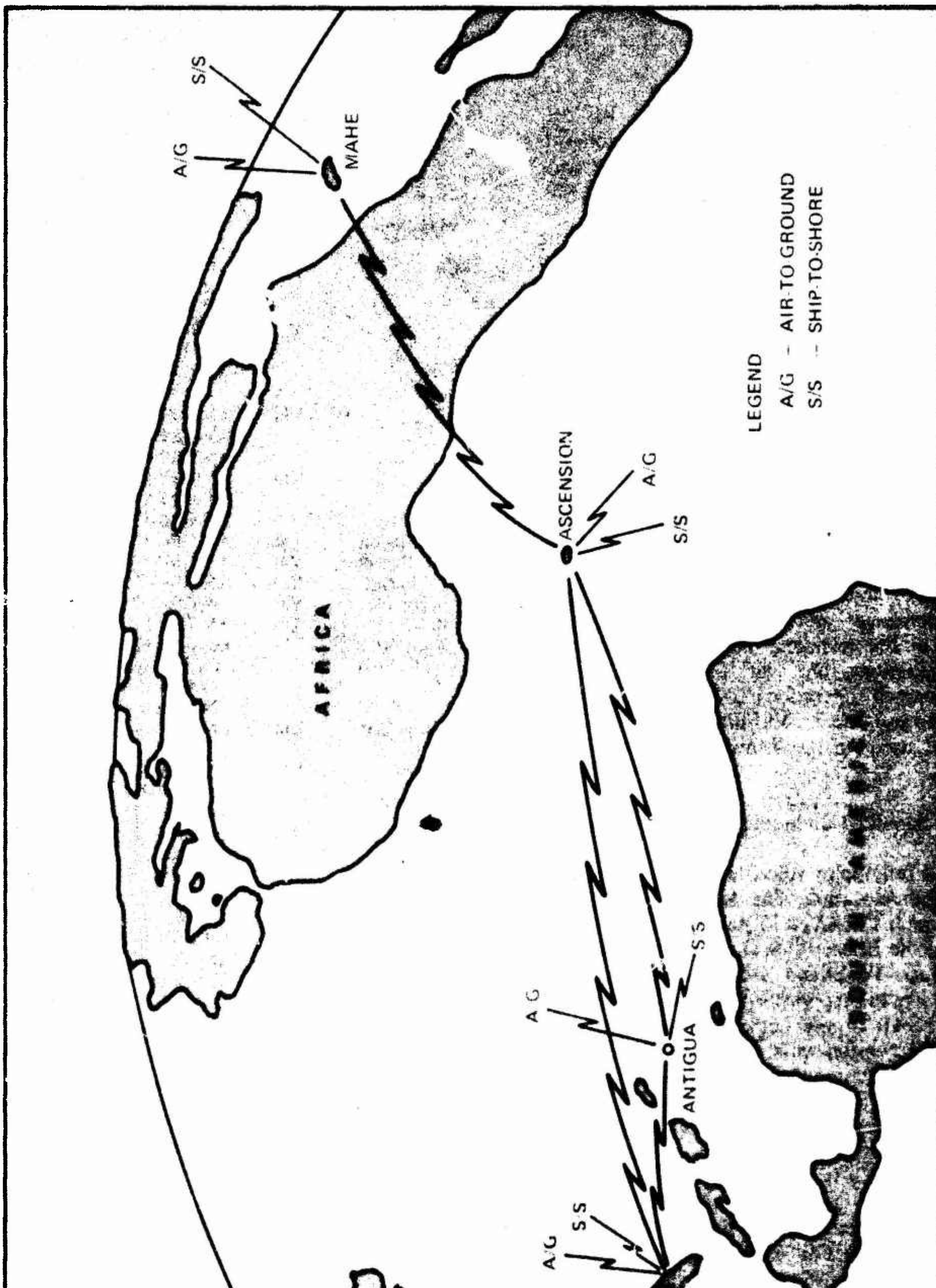


Figure 3-2. AFETR Hf Radio System

whips, two AMC 3010B (vlf), two 5X62 (hf receivers), one SP-600 (hf receiver) with six whips, and two log periodic CA-3038 antennas.

The Landing Craft Utility (LCU) has one RF 201 transceiver (HF/SSB), a 35-ft whip, a Triton vhf radiotelephone (Motorola) with 9-ft whip, Conel (HF/SSB) KR-153SB with 20-ft whip, and a uhf ARC-34.

3.1.1.3 Uhf/Vhf Radio

Line-of-sight uhf and vhf radio is normally used in the ground-to-ground, air-to-air, air-to-ground, ship-to-shore, or ship-to-ship mode of communications. Transmissions normally consist of administrative/operational test support coordination using simplex voice channels. Additionally, up to eight ARIA, which may be scheduled from Wright-Patterson AFB, can provide a real-time voice relay capability between spacecraft and ground stations. Transmissions are either Unified S-Band (2200-2300 MHz) or vhf. The vhf capability is simplex up or downlink utilizing one AN/ARC-34, 100-W transceiver and four vhf crossed-dipoles mounted in the telemetry dome. For unmanned launch operations, uhf, vhf, or hf is used. For manned launch operations, the Unified S-Band system is also used. Vhf/uhf and microwave equipment used on the Range are listed in table 3-2.

3.1.1.4 Satellite Communications

One leased full duplex voice/data channel connects CCAFS and Ascension. The American Telephone and Telegraph Co. (AT&T) portion extends from CCAFS to the Eastern U.S. Gateway terminal. The International Telephone and Telegraph (IT&T) COMSAT channel connects the Gateway terminal via INTELSAT to the Cable and Wireless Earth station on Ascension which is in turn connected to the Ascension communications center by landline.

The AFETR operates and maintains two dedicated SCT-21 Phase II DCSC terminals for SAMSO at Antigua and Mahe Islands. Terminal specifications and operational availability of this dedicated facility can be obtained from the Satellite Control Facility, Sunnyvale, California.

Each of eight ARIA aircraft is equipped with a modified AN/ARC-146 satellite transceiver. The terminal operates in a beacon (receive-only) mode; a full duplex voice mode operating in narrowband fm uses three frequency bands between 240 and 260 MHz for receive and five frequency bands between 300 and 315 MHz for transmit. Transmitter power for the system is variable from 1 W to

Table 3-2. ETR Vhf/Uhf and Microwave Communications Equipment

Location	Type	Model	Qty
CCAFS	Uhf	AN/GRT-22(xmtr)	7
		AN/GRR-24(rcvr)	7
		AN/GRC-171(xcvr)	3
	Vhf	AN/GRT-21(xmtr)	6
		AN/GRR-23(rcvr)	6
		AN/GRC-175(xcvr)	3
GBI	Uhf	AN/GRT-22	3
		AN/GRR-24	3
		AN/GRC-171	1
	Vhf	AN/GRT-21	3
		AN/GRT-23	[illegible]
		AN/GRC-175	[illegible]
Great Stirrup	Vhf	AN/GRC-175	1
Marsh Harbour	Vhf	AN/GRC-175	1
Little Carter	Vhf	AN/GRC-175	1
Treasure Cay	Vhf	AN/GRC-175	1
Little Carter	Vhf*	AN/TRC-1	1
Basset Cove to 8 Mile Rock	Vhf*	Lenkurt 45BX3 Carrier, types 74A2 and 74B1 terminals	1
Treasure Cay	Uhf*	AN/TRC-24	1
Eleuthera	Uhf	AN/GRT-22	3
		AN/GRR-24	3
		AN/GRC-171	1
	Vhf	AN/GRT-21	3
		AN/GRR-23	3
		AN/GRC-175	1
Grand Turk	Uhf	AN/GRT-22	3
		AN/GRR-24	3
		AN/GRC-171	1
	Vhf	AN/GRT-21	3
		AN/GRR-23	3
		AN/GRC-175	1
Antigua	Uhf	AN/GRT-22	1
		AN/GRR-24	1
		AN/GRC-171	1
Ascension	Uhf	AN/GRT-22	4
		AN/GRR-24	4
		AN/GRC-171	2
		AN/GRT-21	3
		AN/GRR-23	3
		AN/GRC-175	2
T-AGM-9/10/20 (each)	Uhf	AN/GRT-22	1
		AN/GRR-24	1
		AN/GRC-171	1
	Vhf	AN/GRC-175	1

1 kW. The antenna subsystem consists of three antennas, a dummy load, a diplexer, an rf sampler, an antenna select panel, and two coaxial relays. The diplexer permits simultaneous transmission and reception using a common antenna. Three antennas give the operator a choice of antenna pattern and polarization.

Each ARIS has an AN/ARC-146 satellite terminal with the identical parameters as the ARIA discussed above. The exception is the antenna subsystem. The ARIS has two bow-mounted steerable (azimuth only) high gain, broadbeam antennas. Each antenna covers 180° from the bow to the stern. The port-mounted antenna covers the port side and the starboard-mounted antenna covers the starboard side of the ship.

3.1.1.5 Microwave System

One microwave link is used on the mainland to connect CCAFS (XY Bldg) and the Malabar transmitter site with a 24-channel breakout at the Patrick AFB Communications Center. This link uses a Collins MW-503 with a Collins MX-106 multiplexer to provide 108 two-way full duplex voice channels.

3.1.1.6 Teletype

The teletype network interconnecting AFETR stations for handling record traffic is shown in figure 3-3. Teletype circuits are multiplexed on 3-kHz voice channels of the undersea cable and hf radios. Message traffic is received and routed in both DD form 173 and JANAP 128 formats. Provision is made for handling both classified and unclassified traffic. Typical equipment used includes: AN/FGC-69, AF/FGC-97, II 333/UG12TD, II 47D/UG, AF/FGC-96, AN/UGC-32, AN/FGC-58, AN/UGC-32, and II-70A/UG. Dedicated, conference, and shared-use circuits are available depending on the type of service required as well as the quantity and precedence of traffic.

3.1.1.7 Voice Communications

The AFETR's administrative telephone system can handle all official calls. Limited secure voice systems are available for official use by authorized personnel.

Direct-dial circuits connect Patrick AFB and CCAFS with downrange subcable stations. Manual patch through the CCAFS/Malabar hf transmitter connects the ships, aircraft, and other stations which are not on the undersea cable.

Three intercommunications systems extend throughout the mainland and downrange instrumentation and operational control sites. They are the Green Phone, Missile Operation Intercom System (MOIS), and Transistorized Operations Phone System (TOPS).

The Green Phone system is a direct line ringdown system which provides rapid communication for instrumentation supervisors to their operating personnel and to other supervisors. Each supervisor has one or more 10/12-line key panels at his operating position. A call is made by depressing one or more key switches in the top position. Subscribers call simply by lifting the handset. Key panels have visual and audible signaling. Since the system can be battery operated it is not affected by commercial power failures.

MOIS/TOPS are intercom systems which permit selection of a net or nets rather than individual stations. All related operating positions, such as those for telemetry are customarily assigned to the same net. Rotary selector switches on the end instruments are used to select the desired net. MOIS/TOPS maintain usable transmission level with headset operation under severe loading. Access to any net may be limited to certain operators who have previously selected the net.

TOPS is a completely transistorized network system which operates in either a 2 or 4-wire mode with a capability of selecting from 2 to 20 channels with up to 250 subscribers per channel. A variety of end instruments are available for use in indoor or outdoor weather. An explosion-proof end instrument is available for hazardous areas.

3.1.2 Range Communications Control Centers

Operations control of ETR communications is exercised at communications control centers at each major station. These centers allocate, monitor, and maintain transmission quality on all on- and off-base circuits and technical operations nets for their station. Equipment and capabilities are limited to manual and semiautomatic operation. See table 3-3.

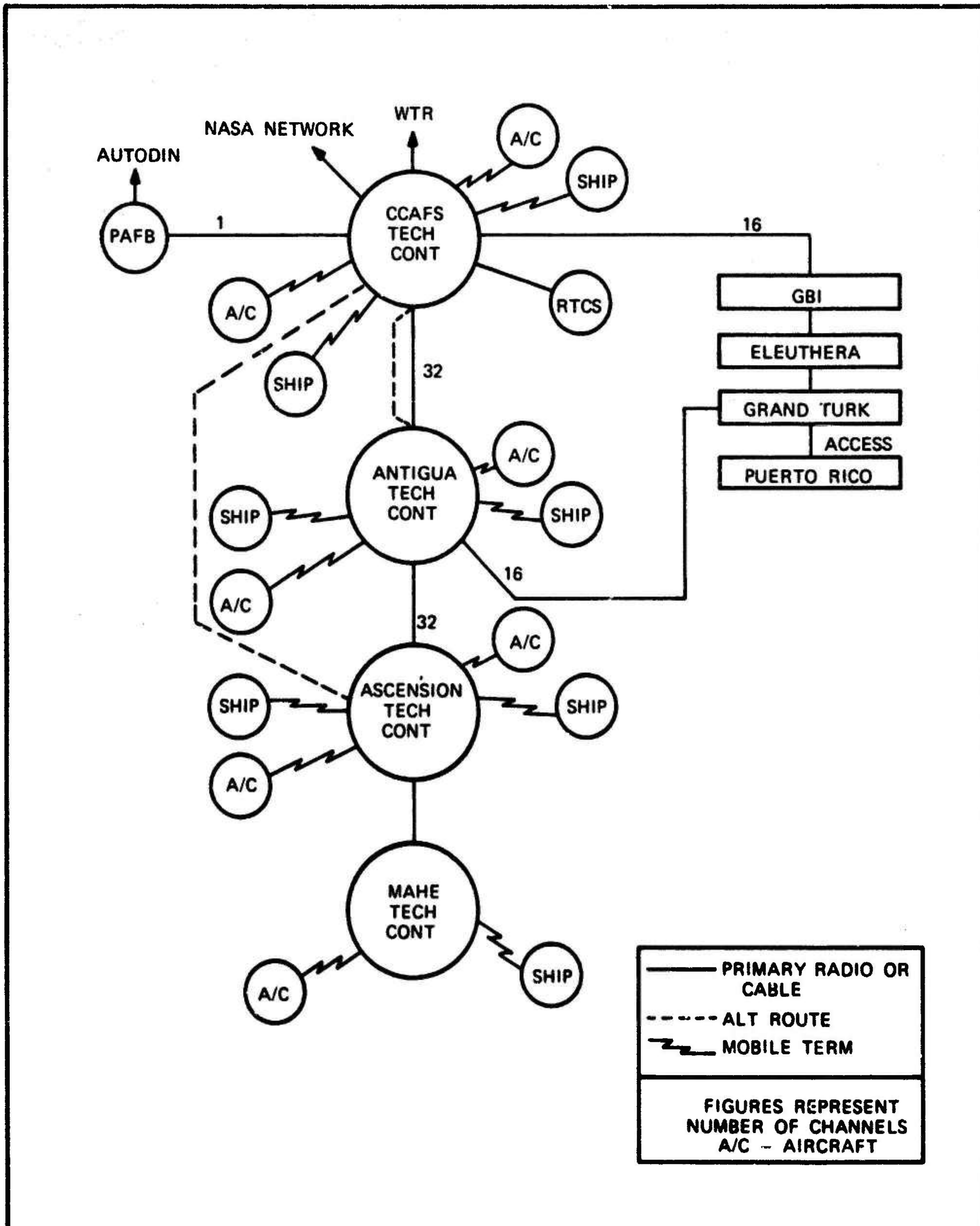


Figure 3-3. ETR Teletype Data Network

Cape Canaveral is the communications focal point for all Range circuits, Range User nets, and commercial carrier interconnect to all other Government agencies. Antigua is the nodal point for the Caribbean area. Ascension is the net control station for ship and aircraft operations in the broad Atlantic area, Africa, and the Indian Ocean area. Antigua and Ascension have complete manual and semiautomatic Range Communications Control Center capabilities.

Audio recorders are used at CCAFS and downrange stations to record selected voice channels during operation support. At present, the Cape can record 160 voice channels simultaneously at 15/16 in/s. The audio recorders are located in the XY Bldg and are used in a fail-safe operation with automatic changeover to a backup unit upon failure or reaching the end of tape. By this method, reliable recordings can be made of 100 channels up to 24 hours. Thirty 4-track 2-channel playback and tape reproduction units provide 60 channels with voice-operated control. These units permit reproduction of recorded information, eliminating all dead space from the data. The system also has two variable speed reproducers and an automatic time announcer.

3.1.3 Closed-Circuit Television (CCTV)

Closed-circuit television on the ETR is generally limited to Patrick AFB and CCAFS except for boresight TV cameras on precision radars and optical instrumentation. The systems are used for management and test operations support. TV systems used for test operations support include cameras for launch pad area coverage, spin test facilities, display information distribution, etc. Only black-and-white coverage is available using standard commercial quality equipment. The television operations center (TVOC) is centrally located at Cape Canaveral. This center has video tape recording, distribution, switching, monitoring, and quality control capability. Video signals from fixed installations are distributed by 16-gauge, individually shielded wire pairs especially designed for the purpose. Wideband transmitters, receivers, and repeaters are used for amplification and equalization of circuits. Repeaters are spaced approximately 3 miles apart for quality transmission of signals with a bandwidth up to 4.5 MHz.

3.1.4 Intrastation Communications

All AFETR stations have outside plant cable distribution systems. Most of this cable is installed underground; however, in coral or rocky terrain the cables are suspended from poles. The service can be extended by installation of lateral cables from the feeder cables. Nonloaded and loaded 19 and 22 gauge cables are used. In addition to these cables, a number of special wideband 16-gauge balanced pairs are included for data transmission. These special pairs are individually shielded and can be equalized to a 4.5-MHz bandwidth.

TABLE 3-3. COMMUNICATIONS CONTROL

Circuit	CCAFS	GBI	GT	ANT	ASC
Dc patch capability (red/black lines)	300/275	26/74	100	200/200	200/275
Audio patch capability lines	1225	300	100	300	400
Automatic audio switch lines	1650	–	–	–	–
Communications switch lines	240	–	–	–	–
Line level adjust 4-wire circuit	1275	200	112	300	400
Conference amplifiers (6-way)	180	30	19	–	–
Conference distribution amplifiers (8-way)	2	–	–	–	–

3.1.4.1 Voice Communication

All intrastation administrative and operational voice communication are conducted by local telephone and interphone systems using the same end instruments previously described.

Additionally each mainland and downrange station has a public address/aural warning system used for local area personnel paging, dissemination of test support and countdown information, and emergency warning and instructions.

3.1.4.2 Downrange Microwave

A Lenkurt microwave system using a 45BX3 carrier and type 74A2 and 74B1 terminals is installed between Basset Cove and Eight Mile Rock, Grand Bahama Island.

Antigua Air Station utilizes a microwave system between the main base and the transmitter site at Parham Point. The system uses four Lenkurt 74B1 microwave receive/transmit units with two Lenkurt 46A2 channel multiplexers to provide 24-channel duplex service.

Mahe Island utilizes a 24-channel ATRAX system between the transmitter and receiver sites and between the technical site and receivers.

3.1.4.3 Intrabase Radio

Each station maintains a two-way base station for administrative and emergency voice communications. The base station uses a 60-W Motorola type C536KB-1100B narrowband fm transceiver which normally connects the base communications center, fire and security headquarters, runway control tower, and base powerhouse. Mobile units are usually installed in ambulances and in vehicles operated by the USAF Base Commander, Range Contractor Base Operations Manager, and fire and security. These units are usually mobile two-way Motorola Model U43HHT-543HHT with 25 W power.

Additionally, Range and Range User personnel use two-way simplex hand-held walkie-talkies for specialized voice communications.

3.2 COMMAND/CONTROL

The ETR Command/Control System consists of a network of radio transmitters at Cape Canaveral Air Force Station, Grand Bahama, Antigua, and onboard the USNS Redstone. The land-based sites are linked to the CCAFS Range Safety Officer (RSO) console located in the Range Control Center for center point control operation, and are used by Range Safety Officers to transmit arm-and-destruct commands to missiles and spacecraft. Range User application of the system includes transmission of commands such as command safe, engine cutoff, and retrofire, and transmission of tones for vehicle control.

For northerly launch azimuths the NASA Bermuda and Wallops Island stations are used by Range Safety when additional coverage is needed. The Bermuda station is a prime support station for NASA manned launches, but is considered backup for DOD launches also.

The Command Destruct System on the USNS Redstone provides the capability for mobile command transmitters. This system primarily supports the USN Fleet Ballistic Missile Programs in conjunction with the Launch Area Support Ship (LASS) from which the request for flight termination is made.

Each of the ETR transmitter sites, the USNS Redstone, and NASA's Bermuda station have two high-power (10-kW) transmitters, while the Wallops Island transmitter is limited to 600 watts. The ETR Cape site can also transmit low power (600 W) signals for use in the launch area.

3.2.1 Land-Based System

Commands are initiated by the RSO, or the flight controller in the case of Range Users, by closing a switch. The switch closure from the console is converted to a MIL STD 188 compatible serial output by dual-redundant encoders installed in the Range Control Center. This output will be routed via the Range Instrumentation Control System (RICS) to the remote command transmitting sites at CCAFS, Grand Bahama, and Antigua. A command decoder and verifier decode the command from the serial data and, as appropriate for the mission, keys the audio from the tone encoder or the digital Range Safety encoder. The encoder output frequency modulates the carrier and the composite signal is radiated to the vehicle (only one station radiates at a time to avoid mutual interference). At the same time, the output of the transmitter is detected before reaching the transmitting antenna and applied to a receiver/decoder, the output which is recorded on a strip chart and also transmitted back to the RSO (or flight controller) via the remote control group to show the command has been transmitted.

The vehicle receives the rf signal, detects the coded command, and passes it to the decoder. The decoder output is a relay closure which activates the destruct mechanism (or causes some other desired action such as fuel cutoff). Telemetry may or may not report on vehicle response to commands but generally does report received signal strength. The rf signal is a frequency-modulated carrier (406-450 MHz) and the carrier deviation is selectable from ±30 to ±300 kHz. The modulating signal is supplied by audiotone coders.

The ground equipment can be divided into three groups: remoting, coding, and transmitting. Redundancy is used within each group to obtain high reliability. The interconnection of these three groups is always the same although the amount of equipment varies from station to station. A typical downrange system is shown in figure 3-4.

3.2.1.1 Remoting Group

A means of directly controlling the command/control encoders and transmitters at Cape Canaveral, Grand Bahama, and Antigua from the Range Control Center at Cape Canaveral is provided by the RICS and local remoting links. The latter consists of frequency shift key (FSK) tone equipment which transfers closures from the RICS terminals or the local RSO console at a given station to the remote transmitter site. Thus, any station can be selected either manually or automatically by a station sequencer.

The RICS is a digital supervisory control and communications system for rapid message exchange between CCAFS and downrange stations via the undersea cable.

The data conversion subsystem (see figure 3-5) sends Range User commands from Cape Canaveral to the command/control stations. Basically, the subsystem remotely controls 17 relays by frequency division multiplexing 17 tones onto a

3-kHz circuit. Each tone is frequency shift keyed (FSK) to open or close the relay contacts. All 17 tone channels are available to Range Users. At the present time receiving equipment is operational only in the command/control building at Cape Canaveral.

3.2.1.2 Coding Group

The tone encoder can generate 20 subcarrier channels in the 7.5 to 73.95-kHz band. Up to six tones, generated simultaneously, can be used singly, in combination, or in sequence to send a command. The frequency stability of each tone is ±0.5 percent of tone frequency.

The Digital Range Safety (DRS) System is designed primarily for range safety. Each command word is divided into an 8-bit address followed by three bits to identify the command. The coder can handle six commands for each of two addresses for a total of 12.

Each bit in a command word is transmitted by two tones selected from the seven available in the 7-kHz to 16-kHz band. Each bit in the word may be a different combination of two tones (21 combinations are available). The code used by any particular missile may be classified.

A new command encoding/verification system was implemented in late FY-76 to provide a flexible means to generate a tone sequence for Range Safety commands. Up to 16 commands can be generated and verified. Each command consists of up to 15 characters where a character consists of any combination of 8 tones preselected from the 20 available tones. The character rate will be adjustable from 10 to 200 characters per second. The commands will be stored in interchangeable memories. New tone encoder and decoders will also be implemented to accommodate critical timing of the tone sequence.

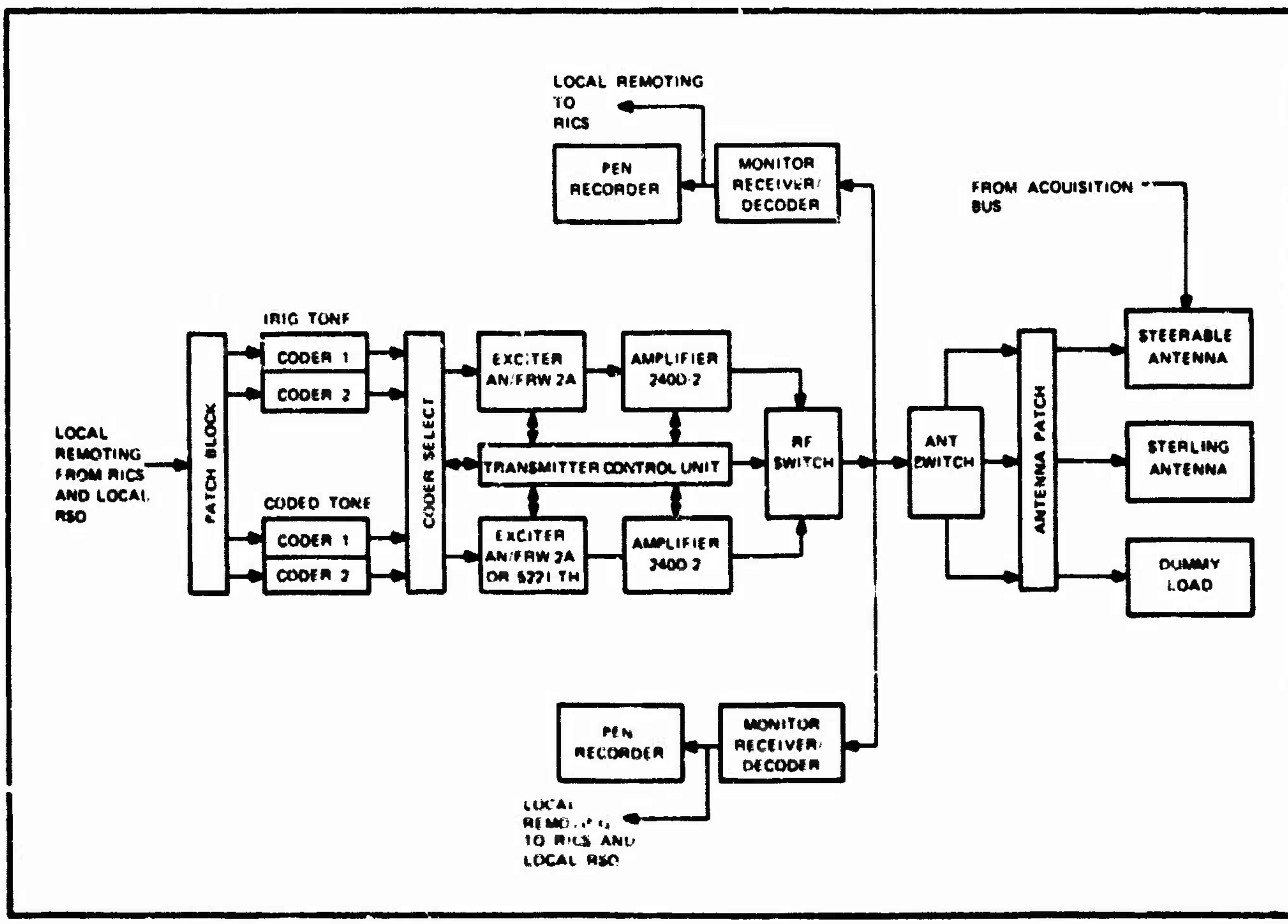


Figure 3-4. Typical Downrange Command/Control Station

TABLE 3-4. COMMAND/CONTROL TECHNICAL CHARACTERISTICS

Antennas			
	Omnidirectional		
	Gabriel Low Power	Melpar High Power	
Gain	Unity	Unity	
Pattern, Vertical	Toroid	Hemisphere	
Polarization	LHC	LHC	
Frequency band	400-550 MHz	400-500 MHz	
Max input power	2 kW	10 kW	
	Steerable		
	Esco	Canoga	Helicon
Gain	15 dB	18 dB	6 dB
Beamwidth	18 x 30°	20°	70°
Frequency band	400-500 MHz	306-450 MHz	406-450 MHz
Polarization	LHC	LHC	LHC
Max input power	15 kW	10 kW	10 kW
Power Amplifier (High-Power)			
	Land-based Sites	Ship	
Frequency band	400-550 MHz	406-500 MHz	
Bandwidth	3 MHz	3 MHz	
Output power	1-10 kW	10 kW	
Gain	27 dB at 3-MHz BW	33 dB at 3-MHz BW	
Transmitter (AN/FRW-2)			
	CCAFS		
Frequency band	406-549 MHz in 0.5 MHz steps		
Carrier modulation	Fm		
Carrier deviation	±30 - ±300 kHz		
Input voltage	1 V peak-to-peak		
Input impedance	560 ohms		
Input frequency band	600 Hz - 100 kHz		
Max output power	600 W		
Rf Exciter			
	GBI. ANT	Ship	
Frequency band	406-500 MHz on 0.5-MHz steps	406-450 MHz on 0.5-MHz steps	
Frequency stability	±5 kHz	±2.14 kHz	
Carrier modulation	Fm	Fm	
Input level	0 dBm	2.0-20.0 volts p-p	
Input impedance	560 ohms	500 ohms	
Input freq. band	300 Hz to 100 kHz	300 Hz to 100 kHz	
Max output power	100 W	80 W	
Description of Commands			
		Land-based Sites & Ship	
IRIG Tone			
Tones available		20	
Max simultaneous tones		6	
Tone frequencies		7.5 - 73.95 kHz	
Range Safety DRS		Land-based Sites Only	
Tones available		7	
Word length		11 bits	
Tones per bit		2	
Bit rate		116-2/3 b/s	
Word rate		6 per second	
Tone frequencies		7-16 kHz	

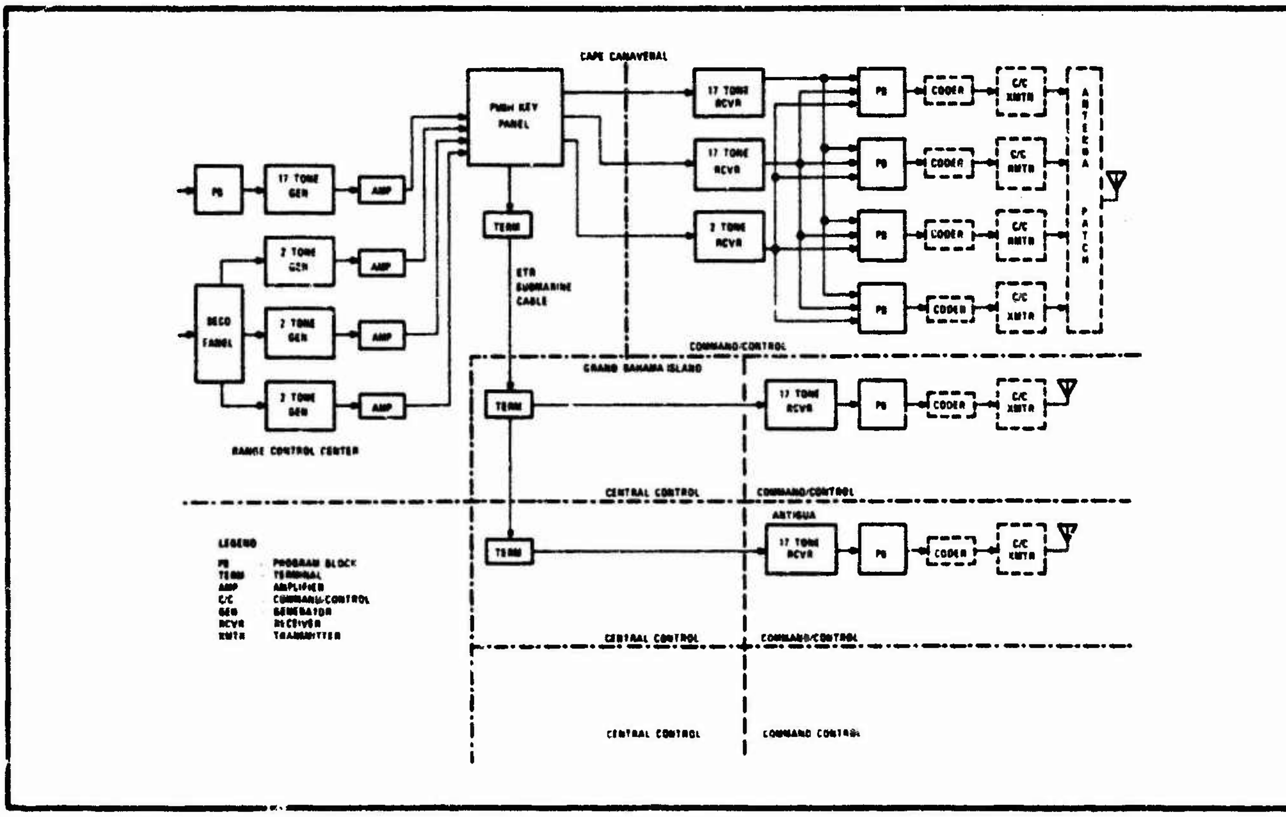


Figure 3-5 Data Conversion Subsystem Block Diagram

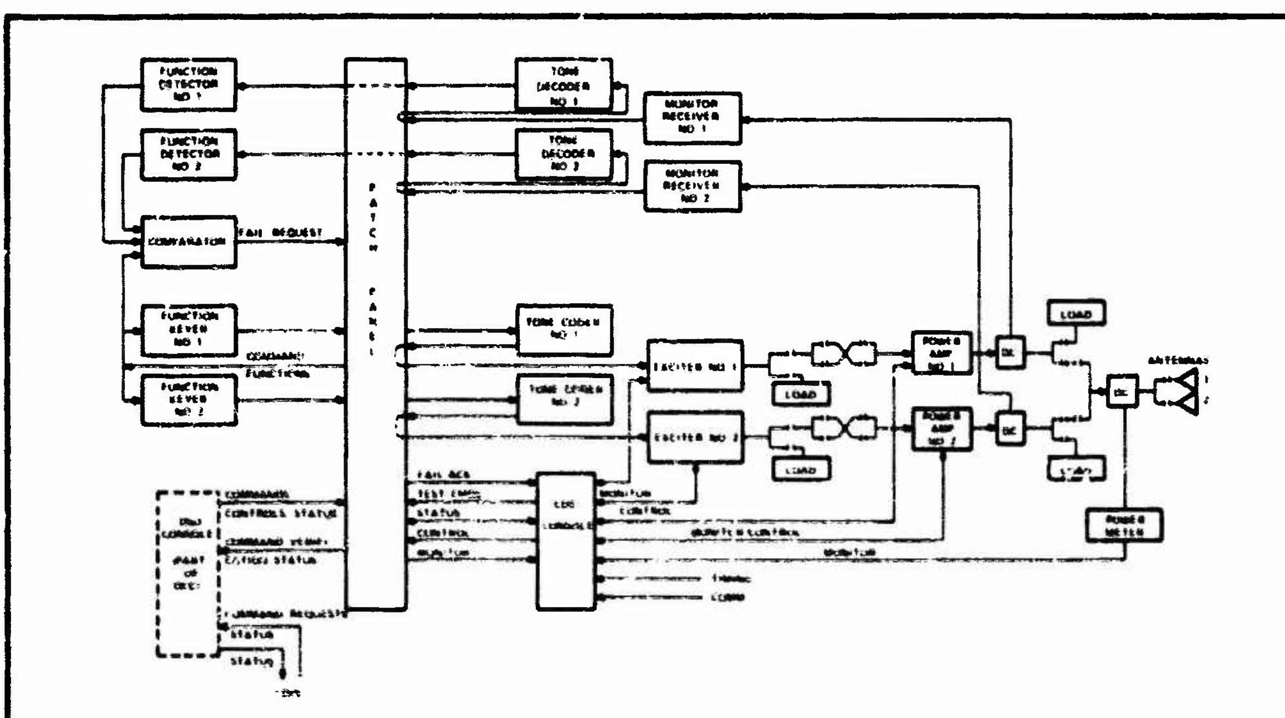


Figure 3-6. Command Destruct System Simplified Block Diagram

3.2.1.3 Transmitting Group

The AN/FRW-2 transmitter, currently used at the CCAFS command control site, is crystal controlled and provides up to 600 watts of rf power. Rf power of up to 10 kW (practical limit of 8 kW) is provided by 240D-2 power amplifiers which are driven by the AN/FRW-2's. At Grand Bahama and Antigua the FRW-2's have been replaced by solid-state exciters having an output up to 100 watts. Dual, low-power solid-state exciters are also scheduled to replace the AN/FRW-2's at the Cape in FY-77.

3.2.2 Shipborne System

The USNS Redstone Command Destruct System (CDS) is designed to permit positive flight termination of errant sea-launched missiles. Arm-and-destruct command functions (coded audio tones) are frequency modulated onto a 10-kW rf carrier and transmitted at the request of the LASS Flight Safety Officer (FSO). The carrier frequency is selectable in 0.5-MHz steps from 406 to 450 MHz.

The Command Destruct System is divided into five subsystems: (1) remote monitor and control subsystem that provides shipboard function activation, monitoring, and distribution; (2) a control subsystem that provides status indications, control functions, and interface connections with system components and other shipboard systems; (3) a local monitoring subsystem that provides demodulated signals for verification of command function transmission; (4) a function keying subsystem for sequencing and activating the proper tone combinations; and (5) transmitting subsystem that performs the modulation, rf power generation, and radiation of energy into space. Figure 3-6 depicts the command destruct system in block diagram form.

3.2.2.1 Remote Monitor and Control Subsystem

The remote monitor and control subsystem is the primary interface for controlling and monitoring the Command Destruct System during normal operation.

The FSO has the option of operating in either manual or automatic mode. In the automatic mode, the link signals from the Central Data Processing System are sent from the FSO console to the Command Destruct System equipment with no FSO intervention. In the manual mode, the link signals are terminated at the FSO console, and Command Destruct System equipment is operated from the FSO console or at the CDS console.

3.2.2.2 Control Subsystem

The control subsystem consists of five bays and the Command Destruct System Console that provides all necessary control functions to operate, monitor, and test the entire system. It also provides an interface with other CDS equipment and with other ship systems.

3.2.2.3 Local Monitoring Subsystem

The local monitoring subsystem is used to verify and record the transmitted functions and the rf carrier level. Events such as transmitted Range Safety Center command functions, transmitted tones, equipment status, system status, and selected mode indications are selectable for inputs to the recorder.

3.2.2.4 Function Keying Subsystem

The function keying subsystem provides a capability for assigning preestablished codes to the four arm-and-destruct function combinations. Any combination of three tones, from a total of 10 tones, can be selected and assigned to each of four missiles.

3.2.2.5 Rf Transmitting Subsystem

The rf transmitting subsystem is a dual/redundant transmitter group, consisting of a tone coder, an fm exciter, a power amplifier, and an rf switching antenna and dummy load assembly.

The exciters provide a nominal 15 watts drive power to the 10-kW power amplifiers. The exciter output is frequency modulated with audio tones from a tone coder and has a frequency in the 406 to 450 MHz range. The power amplifiers provide 10 kW of rf power to the rf switching and dummy load assembly which transfers the power output to one of two antennas or to dummy loads.

Rf is radiated by broadbeam helical antennas. Dual antennas are provided, and each is mounted on elevation-over-azimuth pedestals. Directional control is accomplished with elevation and azimuth manual controls on the pedestals. The antenna can

be positioned from +10° to +80° in elevation and ±90° in azimuth.

3.2.3 Summary

Location and capabilities of each command/control station are given in table 3-5. Each downrange station and the USNS Redstone has one complete high power dual redundant transmitting system. The Cape has three complete dual redundant systems: one high power, one low power emergency backup, and one low power system for local pad support.

TABLE 3-5. COMMAND/CONTROL STATION LOCATIONS AND CAPABILITIES

Station	Max Power	Available Coders			AN/FRW-2	Exciter	Antenna
		IRIG Tone	DRS	Remoting			
Cape Canaveral	600 W	X	X	X	X		Two Canoga (NASA)
	10 kW	X	X	X	X		One Melpar Hi-power omni
							One Gabriel Lo-power omni
Grand Bahama	10 kW	X	X	X		X	Two ESCO
Antigua	10 kW	X	X	X		X	One ESCO
							One TEMEC Dish
USNS Redstone	10 kW	X				X	Two Hi-power Helicon
Bermuda (NASA)	10 kW	X	X			X	Two Canoga
Wallops Is (NASA)	600 W	X	X		X		Two Canoga

KEY: IRIG = Interrange Instrumentation Group
DRS = Digital Range Safety System

3.3 THE ETR TIMING SYSTEM

3.3.1 Cape Canaveral AFS Central Timing

The time signal generators used at the ETR are synchronized to Universal Time Coordinated (UTC) with the aid of the East Coast Loran C Chain, operated by the U.S. Coast Guard, and closely synchronized to the U.S. Naval Observatory and radio station WWV operated by the National Bureau of Standards.

The time signal generators located in the Range Control Center produce 24 different time codes (presence-absence, pulse width, and pulse position), with frame rates ranging from 1 f/hr to 10 f/s and element rates ranging from 1 p/m to 1,000 p/s. Time words are coded straight binary seconds time-of-day, modified binary hours-minutes–seconds and 10th seconds time-of-day, binary-coded decimal days-hours-minutes-seconds and 10th seconds time-of-year, and combinations thereof. In addition, 28 pulse repetition rates are produced, ranging from 1 p/hr to 100,000 p/s. All outputs of the time signal generators are fed to a patch panel where plug-in modular distribution amplifiers have input and output signal terminations. Through system patching the following output configurations are possible:

1. High Level Signals. Forty-two channels of high-level timing signals are available to Range User equipment near the Range Control Center, the generating point. Thirty-six channels of dry contact relay closures are also available.

2. Low Level Signals. Sixty-four channels of low-level signals, distributed over the Cape by the communications system, are sent out as low-level spikes to be shaped and amplified by timing terminal units. Fourteen channels of amplitude-modulated sine wave signals suitable for communication line transmission are also available.

3.3.2 Downrange Central Timing

All downrange stations contain dual time-signal generators and a signal comparator. The signal generators at Grand Bahama, Grand Turk, and Antigua Central Timing are identical to those at CCAFS. The signal generators are synchronized to the DOD master clock via WWV and Loran-C with periodic verification by portable cesium clocks.

3.3.3 Terminal Timing Systems

A timing terminal unit consists of a power supply and chassis that accepts modular subassemblies. Five types of plug-in modules are available: (1) code shapers (to develop high-level coded time signals), (2) pulse shapers (to produce high-level pulses synchronized with range time) (3) neon drivers (for high-level signals for neon lamps), (4) sine wave drivers (to produce amplitude-modulated sine waves whose frequency is derived from the repetition rate and the amplitude modulation from the coded time), and (5) tone detectors (which produce high-level signals or relay closures from an amplitude-modulated sine wave). The outputs of the timing terminal units are used for data clocking, neon light timing for metric camera operation, and timing records on magnetic tape and oscillograph charts.

The overall accuracy of the timing signals is deteriorated by transmission delays, the delay of the timing terminal unit, and the response time of the customer instruments. When correlation accuracy better than 1 millisecond is needed, these delays can be measured and incorporated in the data reduction process.

3.3.4 Subcentral Timing Systems

Subcentral Timing Systems at satellite instrumentation sites on the Florida mainland (1) accept and detect a signal from the central timing system; (2) generate pulse rates, coded timing signals, and position identifiers; and (3) provide standard signals to instrumentation equipment and timing terminal units.

The transmission delays are periodically measured and compensated for so that the subcentral sites are within 5 μs of synchronization with the central timing system.

3.3.5 Uhf Timing Distribution System

A Time Division Multiplexed Timing Distribution System (TDMTDS) is in operation at Cape Canaveral.

At Central Timing, an encoder time multiplexes early signals from the generators and distributes

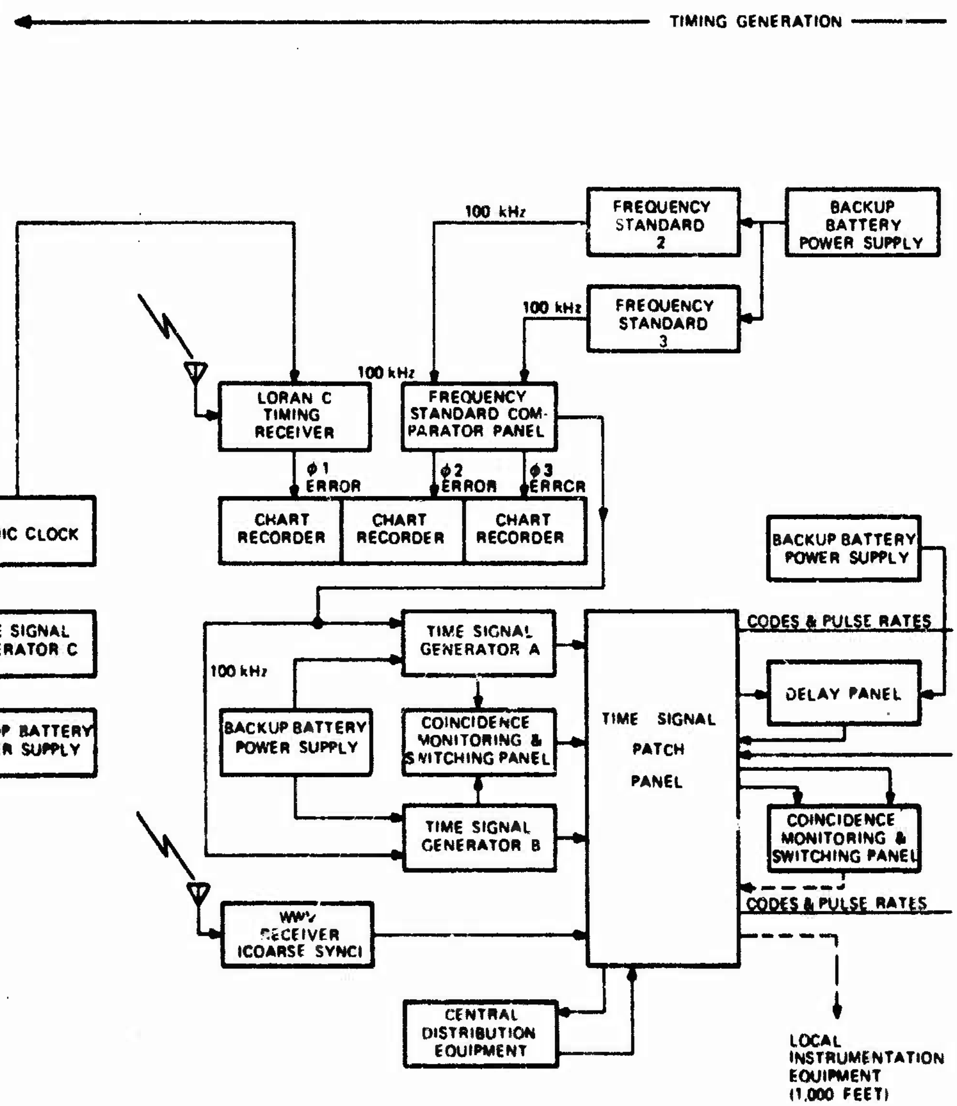


Figure 3-7A. ETR Timing System – CCAFS

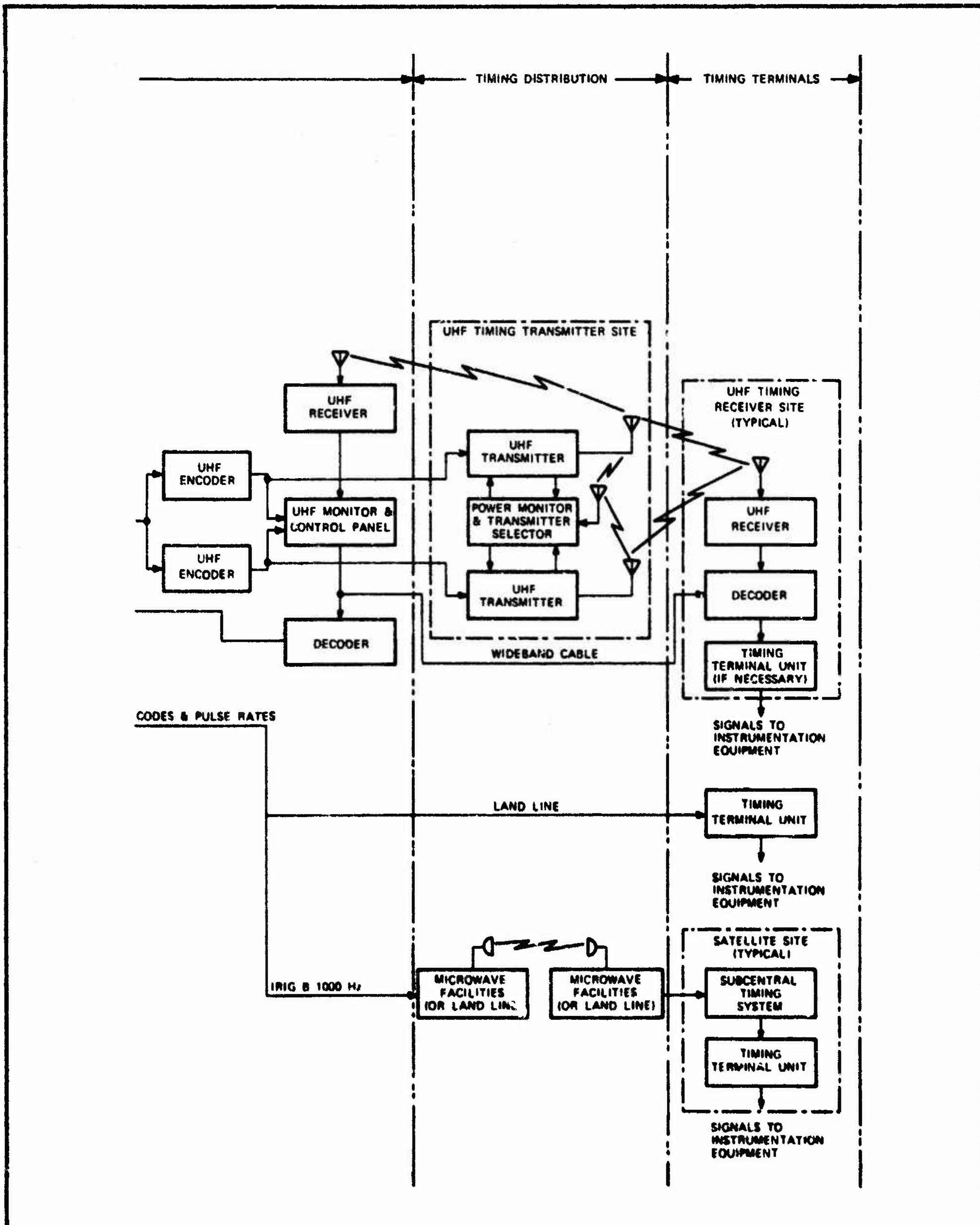


Figure 3-7B. ETR Timing System – CCAFS

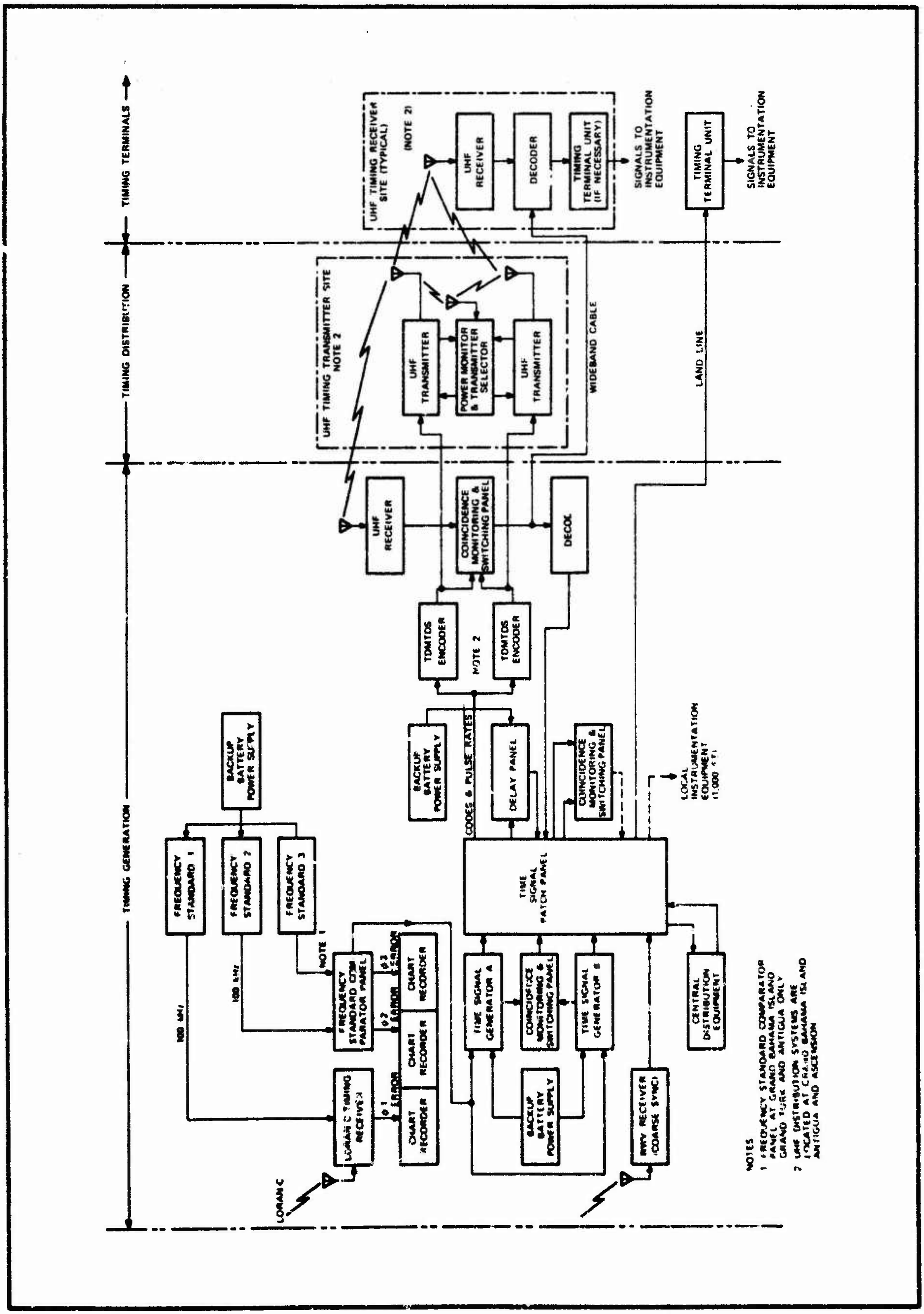


Figure 3-8. ETR Timing System – Downrange (Typical)

the composite signal via wideband cables or uhf radio. Propagation delay is compensated for in the receiving system.

For reliability of radio distribution, redundant encoders and transmitters, with a power monitor, provide automatic switchover if a transmitter fails. The outputs of the transmitters feed omnidirectional antennas. A directional antenna, timing receiver, and decoder at the receiving sites provide outputs suitable for driving standard timing terminal units. Selectable decoder delay, from 200 μs to 1 μs, accommodates propagation delay within a 35-mile radius.

3.3.6 Technical Characteristics (Terminal Timing System)

(1) Output Signal Formats:

See *Pan Am Specification A-600106, Timing Terminal Signals.*

(2) Output Signal Characteristics:

Code and Pulse Shaper Modules:

Output: 0 to +60 V across 300-ohm resistance and 0.10 μF capacitance to a maximum of 200 mA through loads less than 300 ohms. Rectangular pulse with a rise time less than 2 μs and decay time less than 10 μs.

Delay: 5 ±2 μs

Neon Drive Module:

Output: 1 to 15 mA through neon lamp (on an adjustable bias of 50 to 500 μA) shunted by an 0.1-μF capacitor.

Delay: 50+0/-40 μs

Sine-Wave Driver:

Output: 30 V peak-to-peak across 100-ohm resistive load shunted by an 0.015-μF capacitor with less than 5% harmonic distortion.

Phase Jitter: 0 ±10 μs

Tone Detector:

Output: 0 to +60 V across a 300-ohm resistance paralleled by an 0.1-μF capacitor or 200 mA for loads less than 300-ohms, and a relay contact closure.

Delay: 5 ms maximum at 1 kHz, contact closure delay of 5 ms and release delay +20 ms.

3.3.7 Accuracy

Cape Canaveral and downrange central timing systems generate a reference frequency with an accuracy better than five parts in 10 billion (5 parts in 10^{10}). The reference frequency is then divided into slower repetition rates and time-of-day and time-of-year codes are accumulated. The generators used at these stations have "clocked outputs" that cause the leading edges of all code and repetition rate pulses to be coincident to within 1 μs.

The leading edge of timing pulses generated at the following stations is coincident with transmitted UTC with the accuracy shown below. The following list represents the time correlation accuracy continuously maintained by central timing systems with a 3 sigma confidence level. The correlation of the timing pulse furnished to the end or using instrumentation may be less accurate, depending on the method of distribution and the signal furnished.

	Accuracy (μs)
Cape Canaveral	2
Grand Bahama	10
Grand Turk	10
Antigua	10
Ascension	50
Ships	50

If the station has TDMTDS, the correlation accuracy provided to the end instrumentation will be within 5 μs of the timing generator.

3.3.8 USNS Redstone

The USNS Redstone timing system generates and distributes standard frequencies, time codes, and repetition rates for use by shipboard instru-

mentation. The timing equipment is located in the communications and timing center room. Timing system leading particulars are as follows:

1. System outputs – 5 MHz, 1 MHz, and 100 kHz; pulses – 2 p/s, 400 p/s, 2 p/m, and 10 p/m; and time signals – BCD time-of-year to 0.1 s, serial binary time-of-year to 0.1 s time codes IRIG A-H, Central Data Processing (CDP) code (for TOY indicators); sinusoidal signals; square waves correlated to a 1 p/s on-time signal; and square waves delayed with respect to the 1 p/s on-time signal by selectable amounts; all based on rubidium standard.

2. Cesium beam frequency standard "clock" – Hewlett-Packard Model 5061 in system; off-line, as master clock for reference and synchronization. Cumulative time offset of 0.4 μs per day.

3. Rubidium frequency standard – long-term stability $\pm 1 \times 10^{-11}$ per month (maximum limit of drift rate), short-term stability of 5×10^{-12} per second.

3.3.9 ARIS

Dual crystal oscillators provide the timing base for time code generators which feed monitoring and distribution equipment to produce 23 digital codes, 39 mixed codes, 39 pulse rates, and 7 sine waves in the standard, approved IRIG format. Through reception of standard hf broadcast and the use of an on-board cesium beam frequency standard and Loran-C equipment, timing synchronization to UTC is maintained.

Digital time codes are used by the ship computer and for recording on pen recorders, oscillographs, and camera film. Mixed codes, such as a 1-kHz sine wave modulated with a digital code, are used for recording on magnetic tape. Pulse repetition rates are provided for mixing with time codes to interpolate between code pulses and for use as driving pulses for instrumentation equipment. Sine waves provide reference frequencies.

3.4 RANGE COUNT CONTROL

Range Count Control at Cape Canaveral AFS provides:

1. Off-on sequential control of vehicle and instrument functions on a Universal Time base
2. Hold-fire controls for use by Range Safety and Range User instrumentation control
3. Direct reading display of countdown time
4. Dissemination of liftoff time

The system includes a countdown generator in the Range Control Center (RCC), which may be used before start of vehicle countdown, a sequencer in the blockhouse which automatically controls operations during countdown and firing, a real-time programmer in the RCC for programming events according to Universal Time, countdown indicators throughout Cape Canaveral to show the progress of the count, and a distribution system consisting of three nets. The switching of blockhouse and Range Control Center equipment into these nets is controlled from a console at the Range Control Center. These components are further described as follows:

3.4.1 Countdown Generator

A countdown generator in the Range Control Center provides countdown information until T-90 min, at which time the sequencer in the blockhouse switches to the distribution net and provides countdown. The countdown generator also gives positive countdown time after liftoff. The signals produced by the countdown generator are identical to those produced by the sequencer described below.

3.4.2 Sequencer

Three types of sequencers are used: Models II, III, and IV. Because they are functionally similar, the following description of the Model IV can be applied.

Central timing supplies 10-p/s timing signals to a transistorized decade counter which, in turn, supplies a 1-p/s signal to four 12-level, 10-position stepping switches corresponding to units of seconds, tens of seconds, units of minutes, and tens of minutes. The seconds stepping switches provide continuous signals corresponding to tens of seconds and units of seconds for visual display. In addition, the seconds stepping switches generate pulses corresponding to tens of seconds and units of seconds for each second of a minute, i.e., 0 to 59 s. These signals, along with the tenth-of-second signal from the decade counter, are supplied to a one-tenth per second encoder which produces groups of positive signals corresponding to 0 to 0.1, 0.2 to 0.3, 0.4 to 0.5, 0.6 to 0.7, 0.8 to 0.9 for each second of time. These groups of signals terminate in a patch panel for times selection of function relays.

The minutes stepping switches supply visual indicator signals and generate ground signals for each tenth of a second. These pulses are supplied on two lines – one for even-tenths of seconds from -10 to +10 min, the other for odd-tenths of seconds. These signals also terminate on the patch panel. The sequencer control relays (function generators) may be programmed for start-stop at any one-tenth second during the countdown from -10 to +10 min (or at 1-min intervals from -90 to -10 min). This is done by patching in plus signals corresponding to groups of tenth-of-second signals, simultaneously with the particular ground (corresponding to the related even or odd tenth of second) which corresponds to the minute selected.

Visual countdown indicator signals are generated by countdown step switches. A 21-bit (five 4-bit digits and a sign bit) signal is supplied to an encoder which produces an amplitude-modulated 345-Hz signal for distribution. A decoder and indicator present the countdown information.

Two types of hold-fire are possible, automatic and manual. Twenty circuits are provided for automatic hold-fire. During the interval that these hold-fire circuits are programmed, an external condition is sampled. If a malfunction occurs during this time (shown by absence of +28 V dc on the line), countdown will be automatically interrupted. Two modes of restart, automatic and manual, are provided for each programmed hold-fire circuit by means of a selector switch. In the automatic restart position, the countdown automatically restarts when the malfunction producing

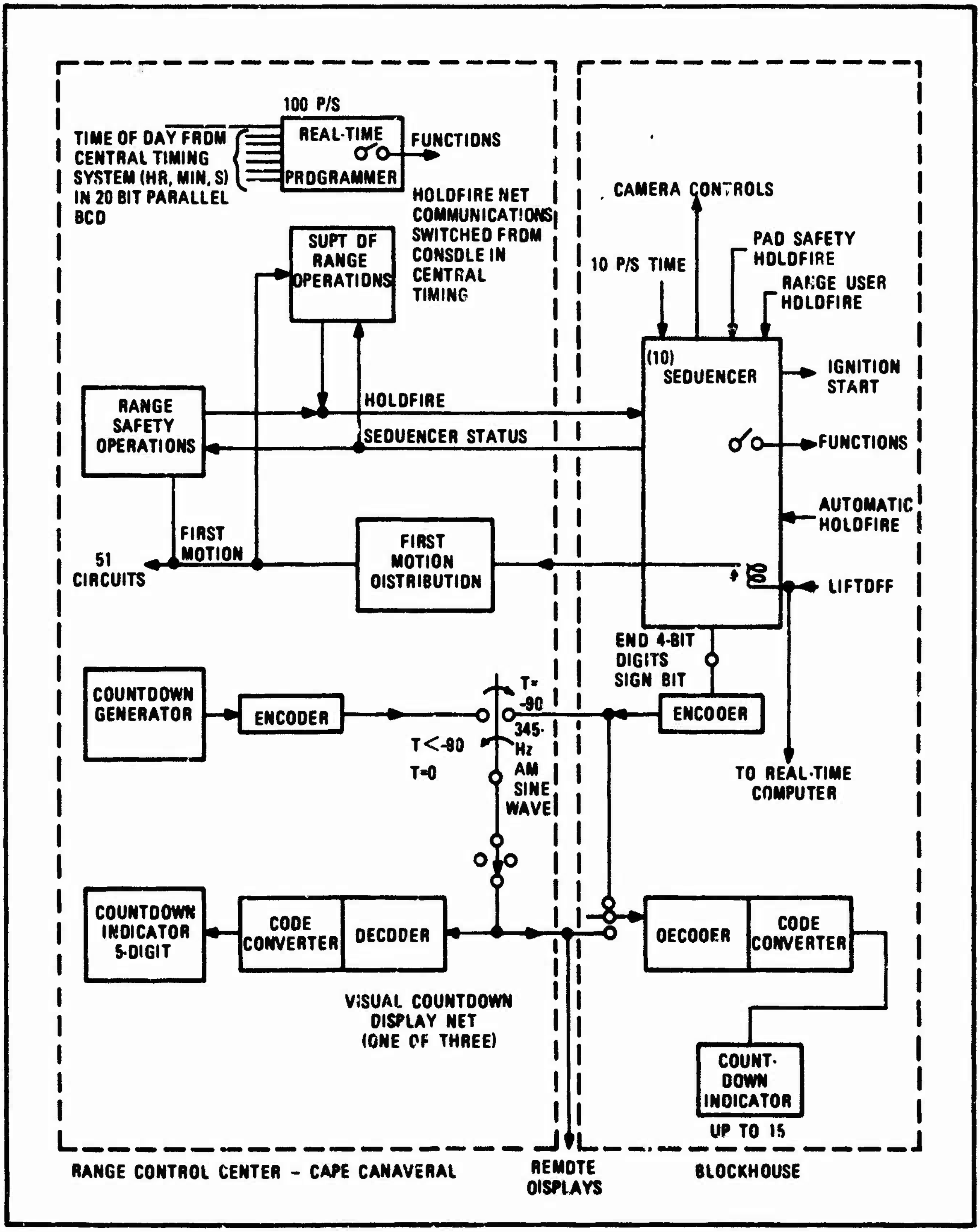


Figure 3-9. ETR Firing System

the hold-fire has been cleared. In the manual restart position, the countdown must be restarted manually when the malfunction has been cleared. Automatic hold-fire override is also provided for each circuit.

The countdown may be manually interrupted by hold-fire switches on the Range Safety, Range Operations, Pad Safety, and Range User consoles.

3.4.3 Real-Time Programmer

By use of the Range Hold-fire Net Distribution System, a precise start pulse is sent from the real-time programmer located in the RCC to the sequencer in the blockhouse. The sequence countdown will then reach T-0 at the predicted Universal Time for T-0 in order that launch program window requirements may be met.

REAL-TIME PROGRAMMER
TECHNICAL CHARACTERISTICS

Input . . . . Second, minute, and hour of day in 20-bit parallel BCD format plus 100 p/s repetition rate.

Function control circuits . . . . . . Ten may be programmed throughout the day in 10 ms increments.

Encoder

Input . . Current pulses of 300 mA peak at 28 V for 20 ms at 1 s intervals.

Operation times . 140 ms read-in, 120 ms readout

Output . . Amplitude-modulated 345-Hz sine wave

Decoder

Input . . . . . Variable, depending on line length

Operation times . . 70 ms read-in, 930 ms readout

3.5 LORAC

Lorac (Long Range Accuracy) is a radiopositioning system operating in the 1.7 to 2.5-MHz portion of the radio spectrum. Lorac provides position information for ships and submarines engaged in launch, tracking, and recovery operations. It also provides a standard of comparison for calibration of a ship's inertial navigation systems and associated equipment. The two Lorac networks installed at the ETR provide coverage from Cape Canaveral to Eleuthera.

A Lorac network consists of three base stations and one reference station. The three base stations are arranged in a triad (one center and two end stations) to provide coverage in the area of interest. The reference station is usually located in the vicinity of the center base station.

The three base stations operate in the continuous wave mode and generate a family of hyperbolas used to provide position information. The reference station operates in the amplitude-modulated mode and provides the reference signal against which the phase measurements are made.

Each Lorac network requires two carrier frequencies: one for the reference station and one for the base stations. While each base station operates on a different frequency from the other two, the difference is so slight the frequencies can be considered the same. The center base station operates at frequency f' while the end base stations operate at f' + 135 Hz and f' – 315 Hz, respectively. The end base station, operating at f' + 135 Hz, is identified as the Green Station while the other is called the Red Station. The reference station receiver receives the three base station signals and produces two heterodyne beat notes, 135 and 315 Hz, in its output. These signals are applied as modulation to the reference transmitter and transmitted at another carrier frequency.

The Lorac mobile receiver operating aboard ship contains two receivers which pick up the signals radiated from the base and reference stations. The outputs of these two receivers are filtered to provide four separate audio tones. Phase measurements are made on the 135-Hz pair and the 315-Hz pair continuously. The phase meters then display the position of the ship in hyperbolic coordinates. These readings are transferred to a navigation chart containing a hyperbolic overlay to determine the ship's position. Alternately, the position can be recorded for later reduction and conversion to any other desired coordinate system. Any number of mobile receivers can use the Lorac network simultaneously since the receivers operate in a completely passive mode.

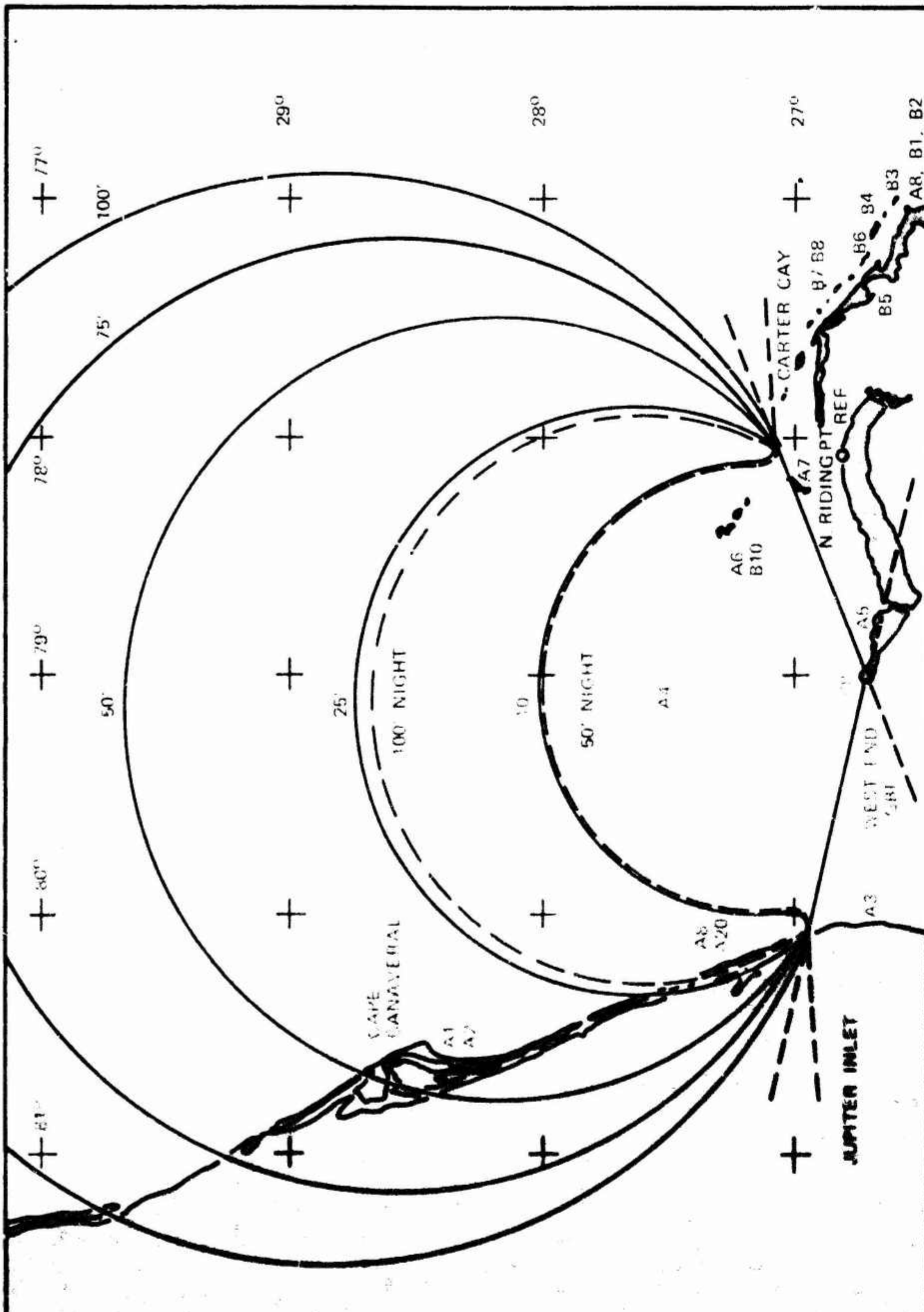


Figure 3-10. Lorac Network A Accuracy Contours

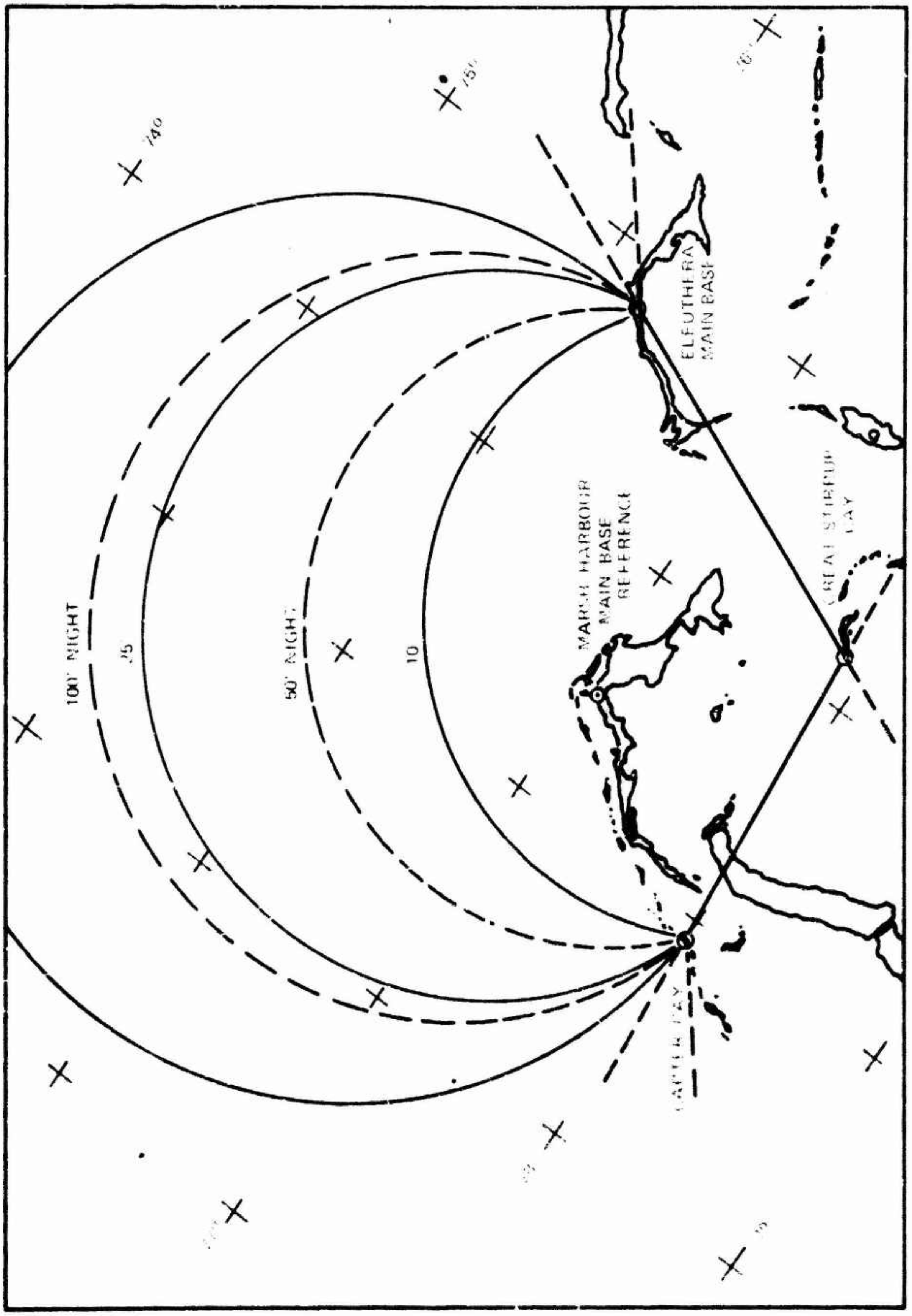


Figure 3-11. Lorac Network B Accuracy Contours

Each Lorac network has the following basic equipment:

Equipment	Quantity
Transmitters, 500 watts, cw	3
Transmitter, 500 watts, a-m	1
Antennas, 240-ft – 280-ft towers	4
Receiver, Pattern Monitor	1

A summary of the Lorac A and B network equipment is provided in table 3-6. The location is as follows:

Location	Frequency (kHz)	Type
Lorac A Network		
Jupiter, FL	1732.135	Green Base Sta
West End, GBI	1732.000	Center Base Sta
Carter Cay	1731.685	Red Base Sta
North Riding Point	1773.000	Reference Sta
CCAFS		Pattern Monitor
Lorac B Network		
Carter Cay	2099.685	Red Base Sta
Great Stirrup Cay	2100.000	Center Base Sta
Eleuthera	2100.135	Green Base Sta
Marsh Harbor, Abaco Island	2415.842	Reference Sta
Treasure Cay, Abaco Island		Pattern Monitor

Error contours for the two ETR Lorac networks are shown on figures 3-10 and 3-11. While the contours are based on the geometric dilution of precision (GDOP), measurements taken against other systems, such as optics and radar, have shown that these errors are conservative.

TABLE 3-6. LORAC EQUIPMENT

Station	Equipment
LORAC A NETWORK	
CCAFS Network Monitor	Receiver & Antenna Strip Chart Recorder Voice Net
Jupiter End Station; GBI West End Center Station; Carter Cay End Station	Transmitter & Antenna Remote Control Equipment Transmitters Receivers Decoders Voice Net
GBI North Riding Point Reference Station	Receiver Transmitter Antenna Calibration Preamplifier Encoder Unit Modulator Unit Voice Net
LORAC B NETWORK	
Carter Cay End Station; Great Stirrup Cay Center Station; Eleuthera End Station	Transmitter & Antenna Remote Control Equipment Transmitter Receiver Decoders Voice Net
Treasure Cay Network Monitor	Receiver & Antenna Strip Chart Recorder Voice Net
Marsh Harbour Reference Station	Receiver Transmitter Antenna Calibration Preamplifier Encoder Unit Modulator Unit Voice Net

3.6 DATA HANDLING

3.6.1 Real-Time Metric Data Handling

Discussion of ETR capability to collect, process, and distribute data in real-time is subdivided to distinguish between "metric" data and "telemetry" data. Metric data, in general, consists of distances and/or angles to a target referred to a specific coordinate system and its origin, and includes data derived from radars and from telemetry antenna angles. In each case, the data are understood to contain correlated time, identifier, and status information.

Figures 3-12 through 3-18 show the configuration of ETR systems that generate and use real-time metric data.

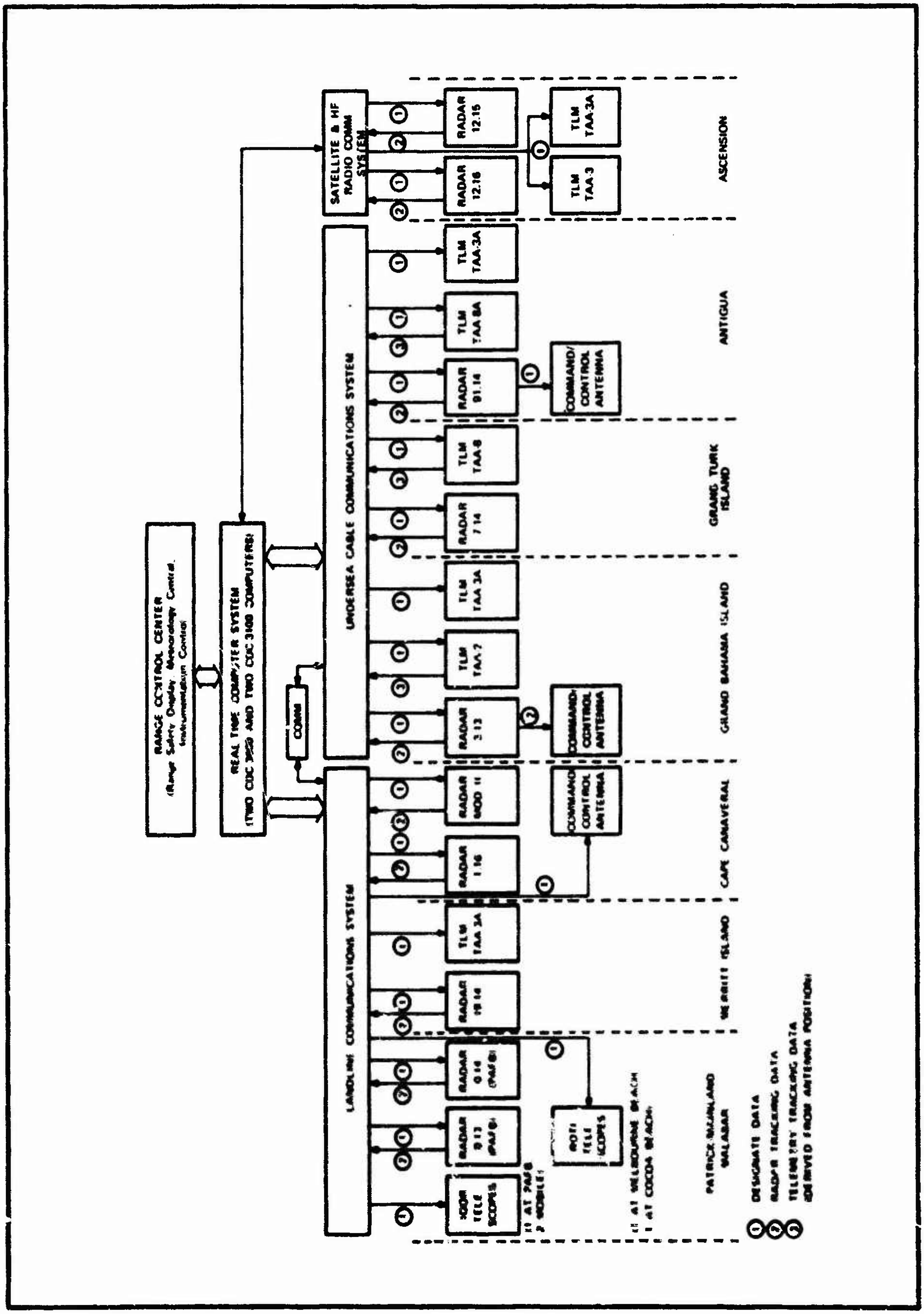
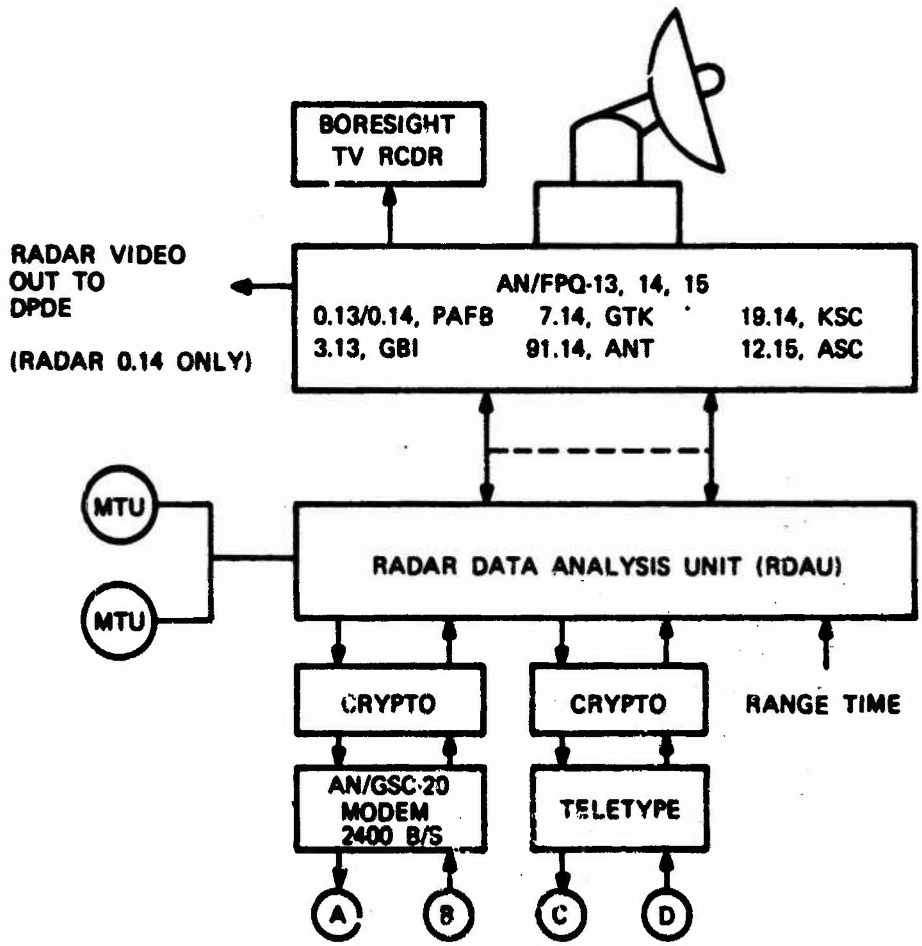


Figure 3-12. ETR Real-Time Metric Data Handling System Block Diagram



COMPUTER

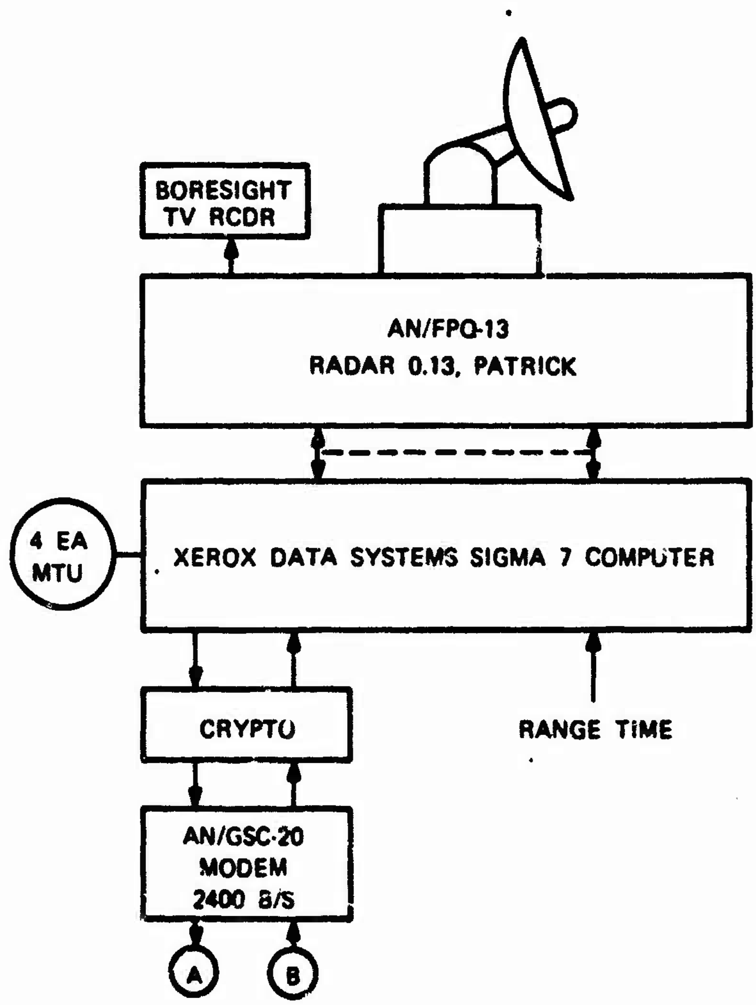
32k words
32 bits/word
950 ns cycle time
200k to 300k inst. per second
6M bytes random access disk *
1 byte = 8 bits

*24M bytes at ASC

DATA NOTES

1. A = Tracking data output includes E,F,G, $\dot{E},\dot{F},\dot{G}$, time, agc voltages, ID, status; 10 samples/second
2. B = Designate data input, same as A
3. C = Interrange Vector (IRV) out
4. D = IRV input, same as C
5. All data input and output circuits are simultaneously connected to the Real-Time Computer System (RTCS) at the Cape, and are available to all other trackers.
6. Boresight TV includes alphanumerics.
7. RDAU Modified Xerox Sigma 5 Computer

Figure 3-13. AN/FPQ-13, -14, -15 On-Site Data Processing



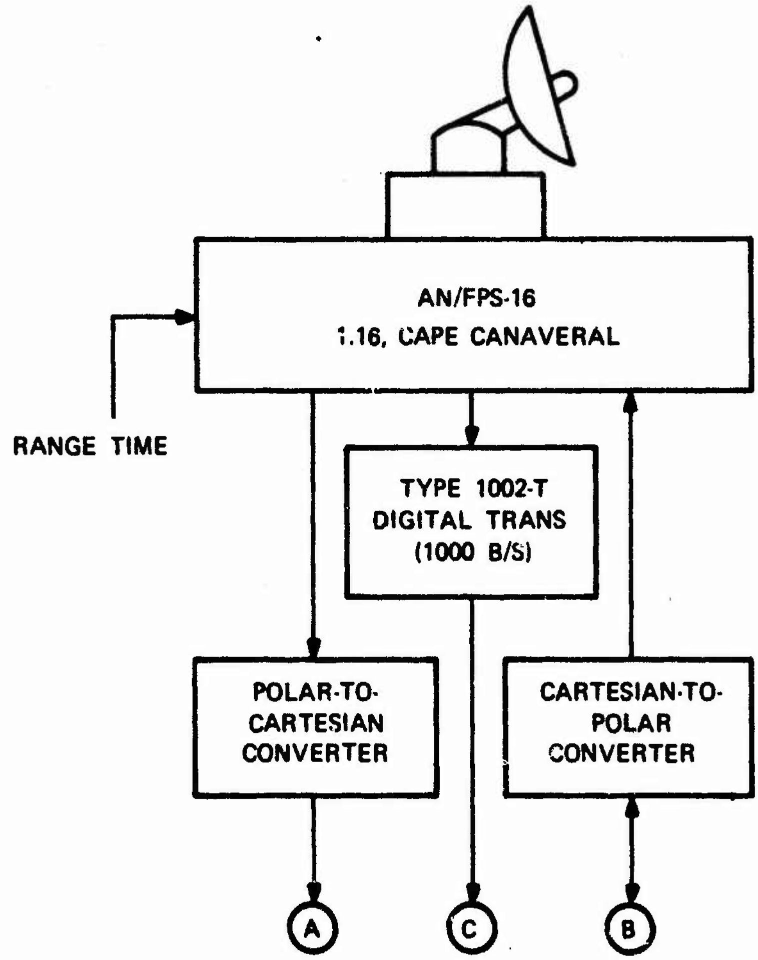
COMPUTER

32k words
32 bits/word
950 ns cycle time
200k to 300k inst per second
6M bytes random access disk
1 byte – 8 bits

DATA NOTES

1. (A) = Tracking data output includes E,F,G, $\dot{E},\dot{F},\dot{G}$, time, agc voltage, ID, status; 10 samples/second
2. (B) = Designate Data Input, same as (A)
3. Interrange vectors (IRV) may be entered or extracted manually.
4. Boresight TV includes alphanumerics.

Figure 3-14. AN/FPQ-13 (PAFB) On-Site Data Processing



CONVERTERS

1. Polar-to-Cartesian converter uses precision sine/cosine and range potentiometers to convert azimuth and elevation angles and range to X,Y,Z coordinates.

2. Cartesian-to-Polar converter accepts X,Y,Z coordinate data in dc voltage form and converts them to azimuth and elevation angles and range data in synchro form.

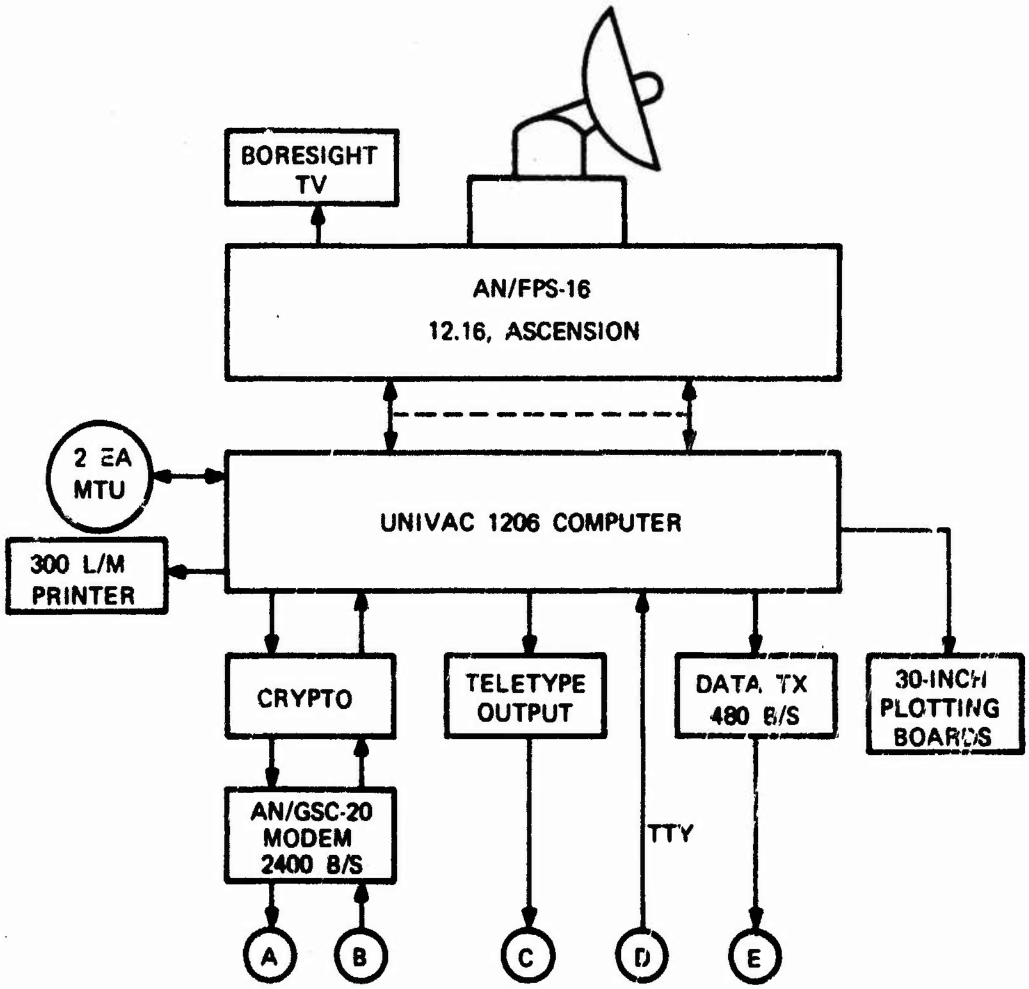
DATA NOTES

(A) = X,Y,Z outputs, in which ± 140 V dc equals ± 10^6 yards. These data are transmitted to Range Control Center, using high-quality cable, to be plotted on charts and to steer certain Range User equipment.

(B) = X,Y,Z inputs identical to (A)

(C) = TAER data in which azimuth angle = 17 bits, elevation angle = 17 bits, and range data = 21 bits. These data are transmitted to RTCS as general purpose tracking information.

Figure 3-15. AN/FPS-16 (CCAFS) On-Site Data Processing



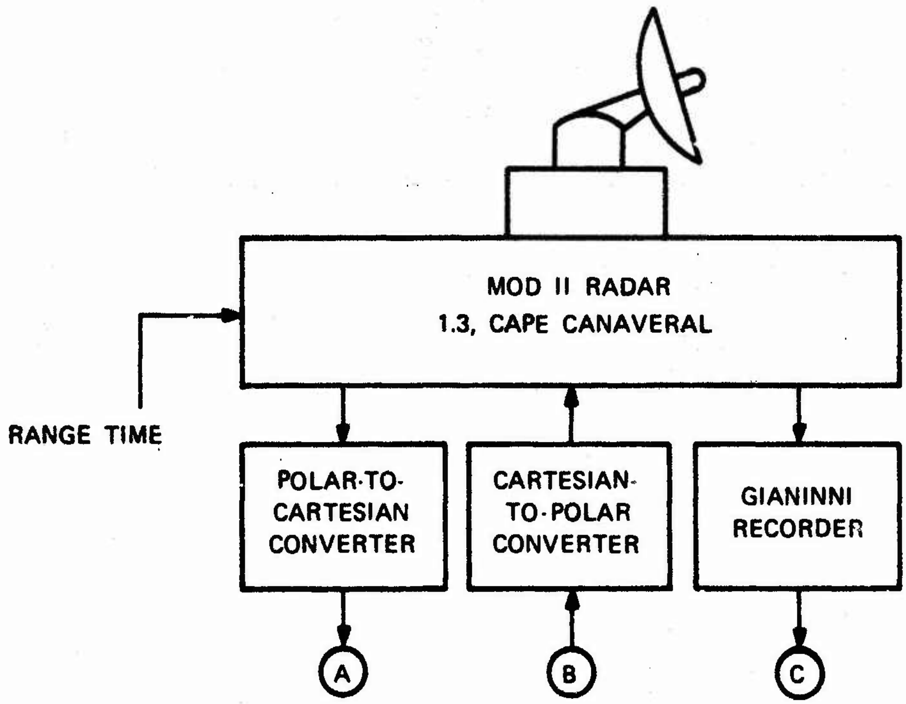
COMPUTER

32 k words
30 bits/word
6 μs cycle time
50 k inst. per second

DATA NOTES

- A = Tracking data output includes E,F,G,$\dot{E}$,$\dot{F}$,$\dot{G}$, time, agc voltage, ID, status; 10 samples/second. Transmitted to other local sites and RTCS.
- B = Designate data, same as A
- C = TAER output via TTY at 1 sample per 6 seconds
- D = Manual Interrange Vector (IRV) input via TTY.
- E = X,Y,Z position, 13 bit resolution in each coordinate, voice bandwidth tone bursts, transmitted via hf radio to S. Africa when required, to provide designate data to Pretoria telemetry.

Figure 3-16. AN/FPS-16 (ASC) On-Site Data Processing



CONVERTERS

1. Polar-to-Cartesian Converter uses precision sine/cosine and range potentiometers to convert angles and range to X,Y,Z coordinates.
2. Cartesian-to-Polar Converter accepts X,Y,Z coordinate data and converts them to azimuth and elevation angles and range data in synchro form.

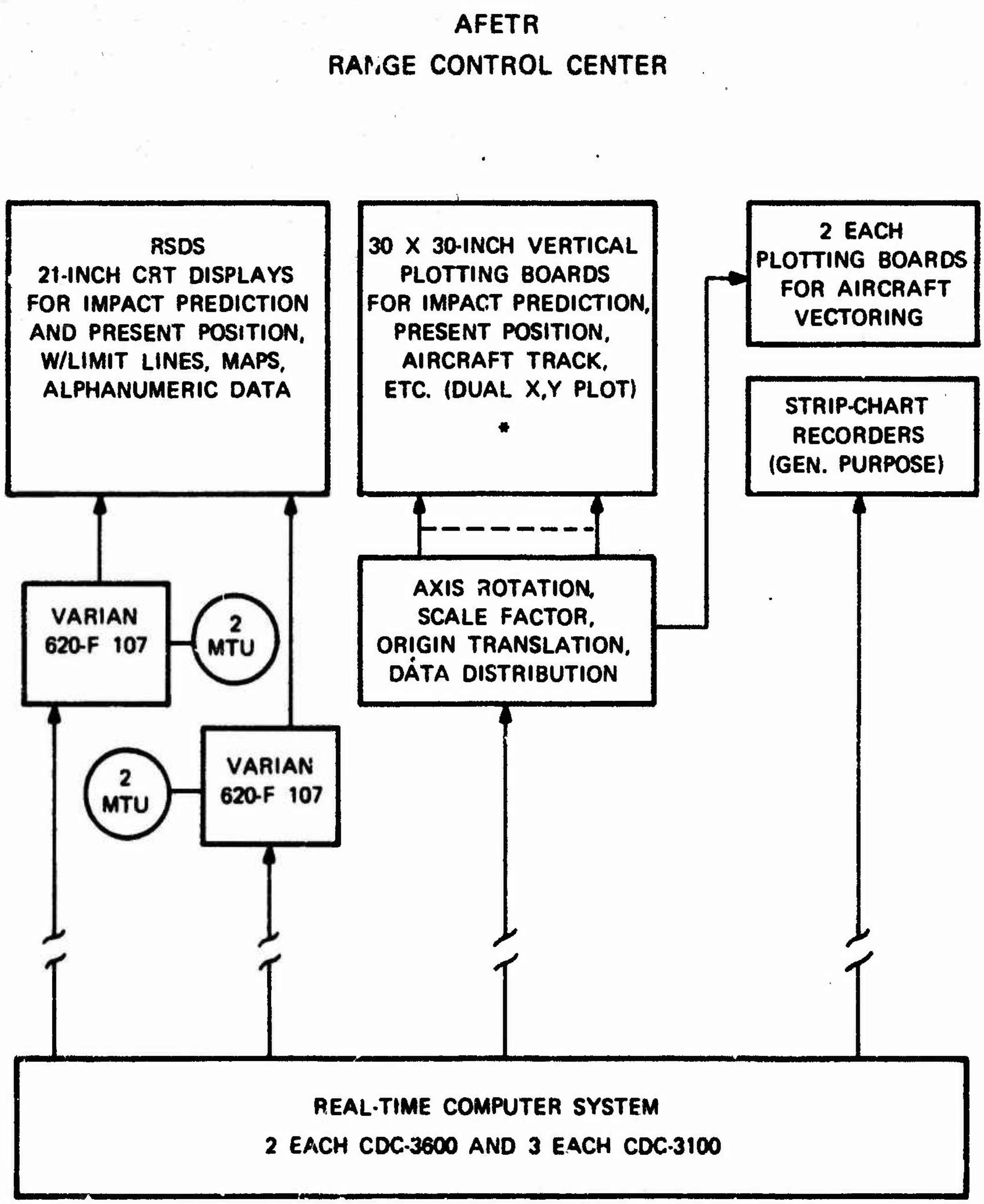
DATA NOTES

A = X,Y,Z outputs in which ± 140 V dc = 10^6 yards. These data are supplied to Range Control Center to plot on charts and to steer certain Range User equipment.

B = X,Y,Z inputs identical to A

C = Paper tape recording of azimuth, elevation, range, and time (TAER) in which the LSB in azimuth and elevation is 0.005 degree, and LSB in range is 1 yard. Sample rate is 2 per second.

Figure 3-17. Mod II (CCAFS) On-Site Data Processing



* WHEN THE RSDS BECOMES OPERATIONAL, THE SET OF PLOTTING BOARDS MAY BE DEACTIVATED.

Figure 3-18. Range Safety/Real-Time Displays

3.6.1.1 On-Site Data Handling

Distance to a target of interest is derived from a range machine in each radar that tracks the target. Azimuth and elevation angles are derived from digital encoders driven by radar and telemetry antennas. Related data, such as automatic gain control (agc) data and timing angles, are derived from appropriate transducers and, together with range and angles, delivered to an on-site computer for processing and formatting to fulfill Range and Range User requirements.

At a typical ETR radar site, data are extracted from the radar at a rate of 160 and 100 samples per second. These data are simultaneously recorded on magnetic tape with correlated timing, and are processed by an on-site digital computer. In one of the processing operations, correction factors are applied to the raw data to remove, to the extent possible, systematic errors such as antenna mislevel and encoder biases. In another operation, the range and azimuth and elevation angles are converted to Earth-centered rectangular coordinates (E,F,G) and their rates ($\dot{E},\dot{F},\dot{G}$), having usual resolutions of 1 meter and 1 meter per second (either of four scales may be programmed and identified). In a third operation, identifiers, scale codes, status signals, and sync signals are generated and added to each sample of data. Finally, the composite samples are formatted as required and readied for transmission at a 10 samples/second rate.

At a typical telemetry site, similar operations are performed with important exceptions. ETR telemeters do not measure range, making it necessary to "dub" in a range to be used with the antenna azimuth and elevation angles in order to derive E,F,G data. This "dubbed" range may be a nominal value inserted manually, or generated using a real or hypothetical trajectory or orbit. In either event, E,F,G data so generated are intended to serve as aids in directing other ETR antennas or sensors to the target.

Metric data derived at an ETR radar or telemeter can be formatted to satisfy any user requirement. The format chosen for internal Range use such as impact prediction and designation consists of eight 30-bit words per sample, with 10 samples per second, giving a data rate of 2400 b/s. This set of data can be transmitted to off-Range Users, when requested, using standard 3-kHz voice channels.

Another set of data can be generated at certain sites, which is suitable for transmission in a teletype format. This set is referred to as an "Interrange Vector" (IRV), and is generated at a rate of one sample per 6 s. Each sample consists of a discrete point and the velocity and time associated with the point, expressed in a format containing E,F,G, $\dot{E},\dot{F},\dot{G}$,T.

3.6.1.2 Data Distribution

The ETR network provides for real-time distribution of data from any source to any and all other locations on or off the Range. The distribution network characteristics and capabilities are summarized below.

Several vehicles tracked by ETR equipment have trajectories that are classified. This makes it necessary to use encryption devices to "secure" the data links. Range Users may, therefore, be assured of complete confidentiality of trajectory or orbit data collected and transmitted over the ETR network. These data can be transmitted off-Range to any user who is equipped to receive encrypted data in the ETR format. In general, ETR circuits use the KG-13 type crypto equipment. Each crypto set is equipped with remote control units.

Real-time metric data are transmitted by various landline modems at a rate of 2400 b/s. When required, AN/USC-12 hf radio modems are used on radio circuits, together with forward error detection and correction (FEDAC) equipment, to transmit data at an effective rate of 1200 b/s. Teletype-like formats are generated by Range computers which can be programmed to produce any of the standard speeds and formats. These formats can be transmitted over conventional circuits to desired locations.

The "standard" link for real-time metric data transmission at ETR is the nominal 3-kHz channel. These links include landlines, microwave links, undersea cable, and satellite relays. A typical data circuit may use all of these links between its terminals. Data circuits are equalized both for amplitude and for differential delay, making them highly reliable in terms of bit error rate. Data circuits extend both uprange and downrange, and are accessible at Cape Canaveral to off-Range Users. Circuits are available in sufficient numbers to accommodate any reasonable requirement.

3.6.1.3 Range-Head Data Handling

The ETR range-head is located at Cape Canaveral, and comprises the Range Control Center (RCC), the Real-Time Computer System (RTCS), and the Communications Central Office (referred to as the XY Building). Data from all ETR instruments are transmitted to the range-head, at which they are received, processed, and distributed to a worldwide network.

The key element of the ETR real-time data handling system is the RTCS, which consists of two CDC-3600 and two CDC-3100 computers. The two CDC-3600 computers are used principally for the range safety task of instantaneous impact prediction. Other major tasks include orbit computations, target designation message generation, and present-position plotting computations. In addition, they compute toxic gas plume diffusion and debris fallout contours, and perform a variety of support computations incidental to missile testing.

An additional CDC-3100 computer is dedicated to real-time weather computations and is interfaced to the AN/FPS-77 weather radar and to the WINDS system. Each of the other two CDC-3100 machines is connected to one of the CDC-3600 computers, and both perform part of the real-time computations during a launch. At other times, they are used as general purpose processors.

One typical aspect of the versatility of the RTCS complex is portrayed in figure 3-12.

During a typical operation, the RTCS is the hub of the ETR data gathering network, and provides position and impact displays to the Range Safety Officer, and computes and dispatches designation messages to a worldwide network of land-based, shipboard, and airborne sensors.

Real-time operation of ETR instrumentation is focused at the RCC located at Cape Canaveral. At this location, all aspects of ETR participation in an operation are managed by a team of controllers. This team includes the Range Safety Officer who is responsible for ensuring that powered flight of a missile or rocket does not threaten the safety of life and property. Other controllers allocate instruments, aircraft, and ships to cover various segments of the flight. Control is exercised by a combination of methods including voice transmissions, automated function control, and preprogrammed contingency criteria. Commands and directions are transmitted by way of a worldwide communications network.

The ETR is fully equipped to serve as a "lead range" to establish and direct large-scale instrumentation networks during missions that require networking outside the ETR boundaries.

The XY Building is the terminal for all communications associated with ETR data handling. This facility is located adjacent to the RTCS and RCC, and provides termination, distribution, and test capabilities for all internal and external ETR circuits.

3.6.1.4 Range Use

Real-time data are used for three primary purposes. First, they form the basis for computing predicted impact point and for plotting present position displays. Second, they are used as designation messages to enable other instruments to find and track the same target. Third, they are transmitted in several formats to Range User facilities such as blockhouse and hangar displays.

3.6.1.5 Off-Range Users

When requested, real-time metric data are formatted, scaled, and transmitted to off-Range User facilities such as Goddard Space Flight Center, Houston Manned Spacecraft Center, and Jet Propulsion Laboratory during manned and unmanned space operations.

In another special application, radar track data are received from SAMTEC (Space and Missile Test and Evaluation Center) while they track a meteorological balloon (ROSE). The RTCS performs a standard computation on the data to derive wind velocity/altitude profiles, wind shear forces, etc, and transmits the results back to SAMTEC. Many similar tasks can be performed by the ETR whenever requested.

3.6.2 Data Processing & Analysis

In general, raw data are received on magnetic tape in digital or analog form, on film of various types,

and on punched paper tape and cards. They are then converted to computer format and processed as required. The results are produced in essentially any format and medium required by the Range User.

A modernization program now underway will allow the ETR to tailor its data processing services to customer needs, and provide products to a wide range of users in a short time. It will also provide the user the flexibility to interact with the processing, in that the processing flow can be altered based on the results of prior runs. This philosophy is based on the fact that total processing needs are difficult to completely define until after the test has occurred. For example, on an operational test and evaluation (OT & E) type mission in which near real-time results indicate a nominal performance, the user may require minimal post-test processing. However, on an R & D mission, processing requirements may require detailed post-test processing to thoroughly evaluate all performance factors. On any mission which experiences anomalies, the degree of post-test processing may be dictated by the determination of the anomaly, which demands a flexible response capability. The ETR supports these needs in a flexible manner tailored to the user.

Several factors make this approach possible:

First, the modernized radars and data transmission system provide a greater quantity and quality of data in real-time. Position, velocity, and status information are available in real-time. Detailed intermediate parameters are available from each site in near-real-time through a digital tape playback over the same data transmission link used for real-time. However, since there is no real-time constraint during playback, there is no limitation on data quantity, and post-test data processing no longer needs to be delayed for transport of detailed on-site data.

Second, real-time data computations can be made and displayed on TV-type cathode-ray tubes for user review. Position and velocity are dynamically computed in real-time for range safety. From this basic information, almost any parameter of interest to the user can be easily derived and displayed.

Third, interactive terminals are being added to the post-test processing system. Software is being developed to allow a preview of results during the processing, with the flexibility to alter the processing flow, and to command the computer to proceed from one processing step to the next. This results in a quick response capability with the flexibility to tailor processing to user needs.

ETR products for users fall into three general areas: real-time, quick-look, and customized.

Real-time data will be conveyed via a TV-type CRT, and will consist of a plot of present position vs time, and velocity vs time, along with alphanumeric status information which describes track status and performance. Special parameters of interest to unique users, and which are derivable from position and velocity, may also be displayed. From the real-time information, the user can gain a preliminary knowledge of performance factors, and pinpoint areas requiring further investigation.

Quick-look data will consist of a printed trajectory defining position, velocity, and acceleration throughout the flight, impact location, and miss distance from target (if required by the mission), and orbital elements (for missile launches achieving orbit). Quick-look data will be available from 20 minutes after testing to 3 days after testing, depending on mission complexity. From the quick-look data, the user can further pinpoint the areas requiring further investigation or processing, and define his post-test processing needs. For nominal OT & E type missions where stringent accuracies are not required, the user may require no post-test processing, and hence avoid further cost or time required. However, a flexible set of post-test products is available as required.

In the post-test processing cycle, a refined best estimate of trajectory (BET) with associated uncertainties can be developed. Also, any event of interest that occurs along the trajectory can be defined. Reentry characteristics can be computed. Signature information can be developed. Additionally, special information that assists the user in assessing performance, determining test vehicle anomalies, or further developing his test model can be provided. Processing will be expedited through the use of interactive processing. Space will be provided for users to monitor the processing cycle, and actually change the processing flow based on results of prior steps if they so desire. The degree to which the user is involved in post-test processing is at his direction, and dependent on his needs. Nominal time and cost information will be

available to assist the user in evaluating cost trade-offs.

These processing services offer users the opportunity to tailor requirements to needs, and dynamically to change requirements as the need arises. It satisfies the low cost, quick response need of some users, while having the flexibility to exercise the complete capability of the ETR for others. It allows the user to be in the loop to the degree deemed necessary for his program (with delivery of data products ranging from hours to weeks dependent on unique needs). It satisfies a very real user need that cannot be met with conventional data processing services.

The ETR data processing staff is supported by a hardware complement consisting of one IBM-360/65 and two IBM-7094 computers and ancillary hardware such as an SD-4060 Printer/Plotter, a Xerox Copy-Flo reproducer, and a Honeywell DDP-116 computer-based signal analyzer.

This section discusses operations performed generally before and after a test, as distinguished from those performed in real-time.

3.6.2.1 Metric Data

The objective of postflight processing of metric data gathered during a flight is to determine, to the maximum degree of accuracy, the trajectories or flight paths and the impact points (or orbits, as appropriate) of objects of interest. These data are then formatted, scaled, oriented, and time-tagged; produced on various media; and delivered to the Range User. The data are also used by Range analysts to measure performance of instruments and to assess data reduction techniques.

Processing of radar data encompasses a great variety of operations. In the best estimate of trajectory (BET) operation, data from tracking radars are combined (with other data) to produce a composite, point-by-point estimate of target position. Data from each radar are subjected to validity tests, corrected to remove known systematic errors, smoothed by a filtering process, and assigned a weight (figure of merit) depending on their ability to contribute to the overall estimate. All parameters are then merged to obtain a composite solution. As many as 100 adjustable parameters can be accommodated in the computer program.

Metric optics data preprocessing is performed on a variety of equipment including theodolite readers, digitized microscopes, attitude readers, comparators, oscillograph readers, and a microdensitometer. This equipment converts the data on films to computer formats and produces them on a punched paper tape, punched cards, and magnetic tape. These data are then ready for computer processing to produce metric information desired by Range Users. Information recovered from raw data includes position, velocity, and acceleration vs time; aerodynamic performance; intercept and miss distance; staging and other in-flight events; and object identification.

The ETR maintains an extensive Missile Impact Location System (MILS) in the Atlantic Ocean, consisting of various arrangements of hydrophones. One such arrangement is an array consisting of six bottom-mounted hydrophones located at each corner of a pentagon and at its center. Sounds arriving at the hydrophones are converted to equivalent electrical signals and transmitted to a shore station, via cable, where they are recorded on magnetic tape. Another arrangement consists of individual, independent hydrophones located at several strategic points in the Atlantic Ocean. These units are suspended at a depth of a few thousand feet and operate in the same fashion as the arrays.

Recordings of hydrophone sounds are processed by a special-purpose computer to extract the desired information. The signals are processed in both the time domain and the frequency domain. Computations on the times of arrival are made to measure the location of the source (e.g., a surface impact or explosive charge). Computations on the frequencies are useful in identifying the nature of the source and distinguishing between multiple sources.

Recorded signals collected from arrays at Grand Turk and Antigua are transmitted from those stations to the mainland by way of undersea cable circuits, and signals from the array at Ascension are transmitted by hf radio circuits to permit rapid delivery of results to Range Users.

Quick-look information from all sites can be relayed to the mainland for immediate use by way of radio or telephone.

3.6.2.2 Telemetry Data

The ETR is equipped to perform all kinds of operations on telemetry data for Range Users. Data received on magnetic tapes are separated, identified, and formatted for subsequent processing. Processing operations such as conversion to engineering units and formatting for plots, graphs, tables, and charts are then performed on the data processing computers. Finished computations may be produced on any of several media for delivery to Range Users.

An important feature of this capability is the large capacity and high speed with which data may be processed and delivered to a user.

3.6.2.3 Signature Data

"Signature" data refers to the kinds of data gathered by radars, optics, and radiometric sensors that characterize and aid in the identification of devices reentering the atmosphere and objects in space. With regard to the ETR data processing capability, signature data refers to the information collected by the two ARIS ships and processed at ETR.

Data are received from the ships on magnetic tapes containing digital, analog, and video recordings and on films. A preprocessing system, called the data playback and digitizing equipment (DPDE), converts the video data into a format suitable for computer processing. Data from film and other media are similarly converted and, together with the converted video and metric data, are processed by the data reduction computers. Results of these processes include number and relative positions of multiple space or reentry objects, shapes and sizes of objects, radar cross-sections, heat and light emissions, ballistic coefficients, accelerations, and other information useful in determining the nature and purpose of the objects.

3.6.2.4 Other Data Processing

The ETR has developed the capability, procedures, and programs to perform a number of special tasks that involve the use of computers. For example, Mechanized Range Scheduling (MRS) is a technique that makes use of teleprocessing to schedule Range activities. It includes a data base containing all ETR instrumentation, and enables accurate and immediate determination of Range availability. It also identifies all resource conflicts and assists users in determining what compromises, if any, can be made in support configuration.

Another example of special-purpose data processing is the Mechanized Range Documentation (MRD) system. The data processing computers are used to produce Operations Directives (detailed directions to instrumentation operators). Interactive processing techniques are applied to enable the most rapid possible response by instrumentation to changes in test support requirements. This gives the ETR a high degree of flexibility with respect to Range User needs.

Both the MRS and MRD techniques are specialized applications of general-purpose information storage and retrieval systems, and are able to accommodate new test programs quickly.

Special meteorological sounding formats are available to meet Range User needs. Meteorological sounding data is obtained from rocketsondes, rawinsondes, jimspheres, etc; computer processed into the format desired; and delivered to users.

3.6.3 Redstone Data Handling

The Central Data Processing System (CDPS) consists of a Univac 1230 digital computer, associated peripheral equipment, and buffers which interface the computer with instrumentation complex equipment.

The Univac 1230 (modified CP-642B) general purpose computer provides a random access memory for 32,608 30-bit words, 16 input and 16 output channels of 30-bit words, and cycle times of 2 μs and 1 μs with memory overlap. The peripheral equipment includes: one 2-deck and one 4-deck Univac 1240 magnetic tape unit; a Univac 1232A input-output console; a Teletype Model 28 Teletypewriter Set (ASR) with Univac 1259 adapter; a Data Products 4120, 600-line/min high-speed printer; raw data recorder; and interface buffers to instrumentation equipment.

The Central Data Processing System receives ship's position and attitude data, timing system signals, antenna pedestal flexure data, control signals, target acquisition information, and real-time tracking data. It processes the received information to provide data for antenna pointing, ship's position and attitude, trajectory data recording and display,

plotting board tracing, target acquisition, and data transmission. Primary operations are accomplished in standby, acquisition, and tracking modes under the management of resident control and executive programs which optimize computer time and priorities. Auxiliary routines and subroutines provide standard library, marine survey, data reduction, system analysis, and checkout routines. Diagnostic routines are provided to facilitate trouble analysis.

3.6.4 ARIS Data Handling

The ARIS data handling subsystem provides for the conversion, formatting, and recording of ship-collected metric and signature data and for the functions of target designation, navigation, calibration, and checkout. A total capacity for processing 33 million bits of data per second exists.

Three major equipment groups make up the data handling subsystem. The first, data processing equipment, includes the central computers, peripheral equipment, and related software.

Video recording equipment provides redundant recording of all radar signature data and includes 2-in magnetic tape units with associated electronics and buffers. Tape copies can also be made aboard ship. The video tapes are played back at Patrick AFB on the DPDE.

IBM 360/65 COMPUTER

Data conversion equipment serves an interface for the processing and recording function by providing two-way conversions between digital and analog data, formatting digital data for recording and computer entry, routing data between subsystems for the tracking radars, and recording all prime target metric and signature data with SINS attitude and other reference data.

The allocation of major equipment for the two ships is shown below.

Equipment	USNS Arnold	USNS Vandenberg*
Computers	1206, 642-B, 1230	1206 and 1230
Video Recorders	4 units	4 units
Data Conversion	CDCE, NDHIS, DRSB, DCISE	CDCE, DCISE

* Future plans call for upgrading this ship to the same configuration as the USNS Arnold.

CDCE – Central Data Conversion Equipment
NDHIS – Navigation Data Handling Interface System
DRSB – Digital Recording System Buffer
DCISE – Data Conversion Interface and Switching Equipment

The computers perform their functions in the systems by the following major programs:

1. Navigation (NAV). Used before and after a launch to determine ship's position and heading. It uses SINS, sonar, and star tracker data.

2. Designate, acquisition, and track (DAT). Used during launch or orbital support to designate tracking sensors onto target, collection of mission data and impact prediction. During DAT, a limited part of the NAV program provides continuity of the navigation routine.

3. Data transcription. Used after the mission to transcribe mission data from the 1-in magnetic RDR tape to IBM 7094 format on ½-in magnetic tape (Vandenberg only).

4. Checkout. Used to check out the computers and associated data processing equipment (DPE) peripheral equipment, and the major subsystem interface.

5. Combined mount misalignment data collection and navigation calibration. Used to determine system misalignments.

6. Quick Look. Used after the mission to obtain cross information on the mission and calibration data.

SECTION 4
RANGE SAFETY

The purpose of the Range Safety System is to ensure an operating environment that permits the maximum flexibility in the achievement of test objectives while reducing the risk to personnel, property, and the test vehicle to an acceptable level.

The Range Safety System provides the Range Safety Officer (RSO) the capability for monitoring missile, space launch vehicle, aircraft, drone, and special testing (e.g., helicopter, balloon, small rocket, etc) conducted on the AFETR.

In particular the system is comprised of the following:

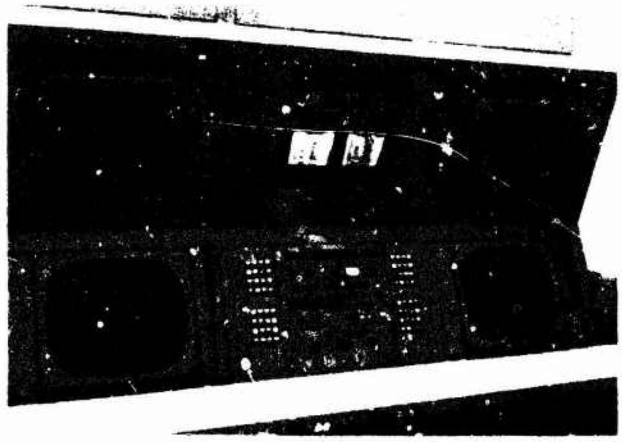
- Range Safety Display System
- Vertical Wire Skyscreen
- Range Safety Closed-Circuit TV
- Plotting Board Display System
- Data Display

All safety information is channeled to one or both of the two Range Safety areas in the Range Control Center. The two areas are functionally similar but vastly different in equipment. One area is the new Range Safety Display System (RSDS) and the other area is the plotting board/console area which was previously the prime system and is now being replaced by the RSDS. Both areas contain displays and instrumentation/capability necessary to provide safety for all testing conducted on the AFETR.

4.1 RSDS

The primary system used by the RSO is the RSDS. It consists of a console with four direct-write cathode-ray tubes (CRT's) whose displays are real-time selectable by either of the two RSO's (figure 4-1). Major components of the system are:

- CDC-3600 Computer System (2)
- CDC-3100 Computer System (2)
- IDIIOM Display System (2)
- Cathode-Ray Tubes (4)
- Console with Auxiliary Capabilities



RANGE SAFETY CONSOLE

4.1.1 CDC-3600 & 3100 Computers

Real-time raw data from radar and telemetry systems are inputted directly into the memories of both the 3600 and 3100 computers in the Real-Time Computer System (RTCS). This data is processed by the RTCS and graphical data such as impact prediction (IP), present position, debris footprint, velocity vs time, and various alpha-numeric data (e.g., plus count, designation of tracking instrument and mode, and altitude and velocity of target) are outputted to the RSDS buffers which are in turn read out by the Varian computer and displayed on the CRT's. All background information such as geographic maps and destruct lines are pretest loaded into the Varian memories. During the test, four separate CRT displays are selectable by the RSO. Normal sequences follow a preprogrammed routine but can be altered by switch selection from keyboards on the RSO console.

Under normal system operation the prime 3600 computer outputs to the RSDS through buffers 1 and 2. The standby 3600 computer generates the debris footprint data and passes it to the prime 3600. Varian A reads data from buffer 1 and Varian B reads buffer 2. Both buffers contain identical data, which consists of all current updates generated by the 3600's.

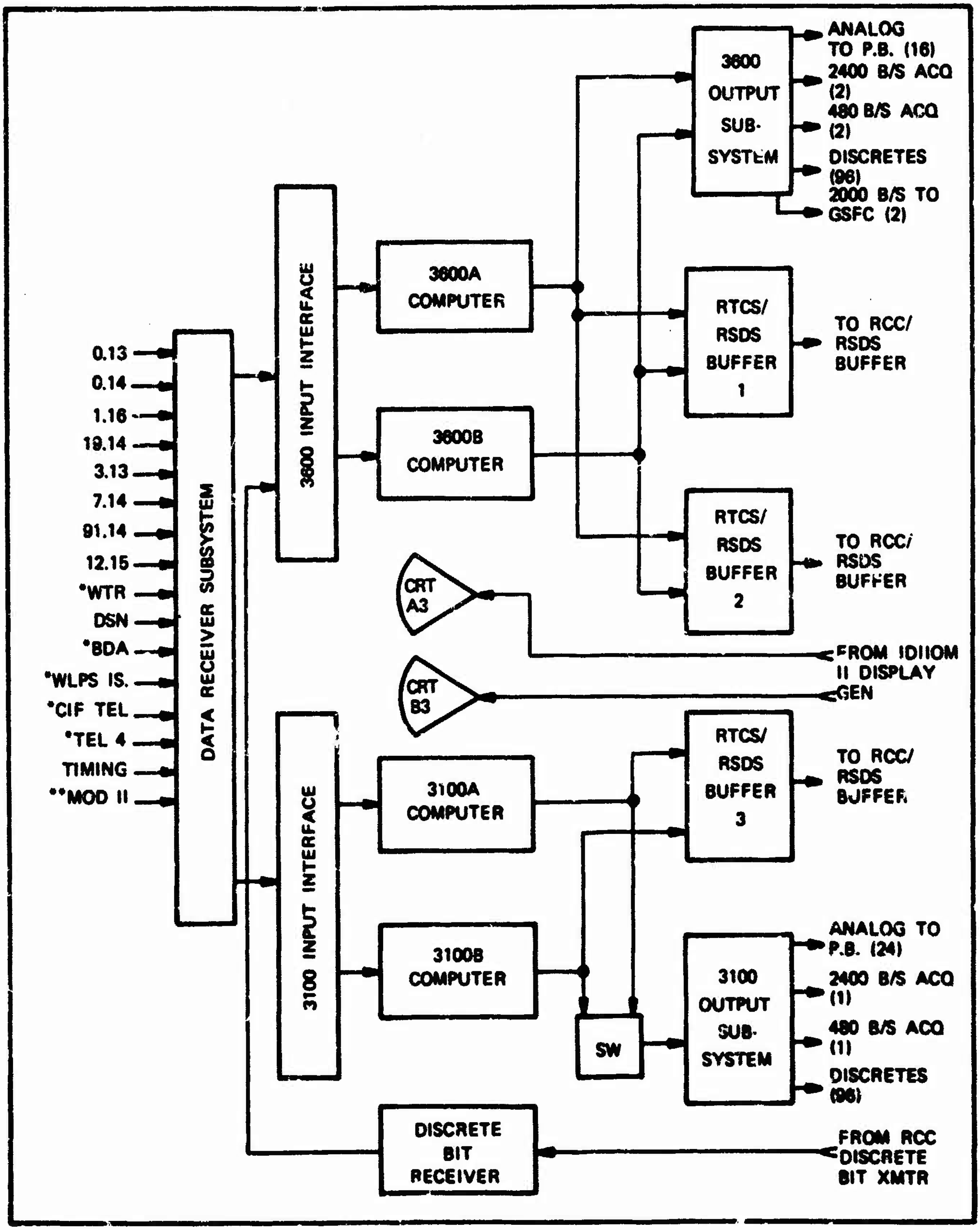


Figure 4-1A. Range Safety Display System Block Diagram

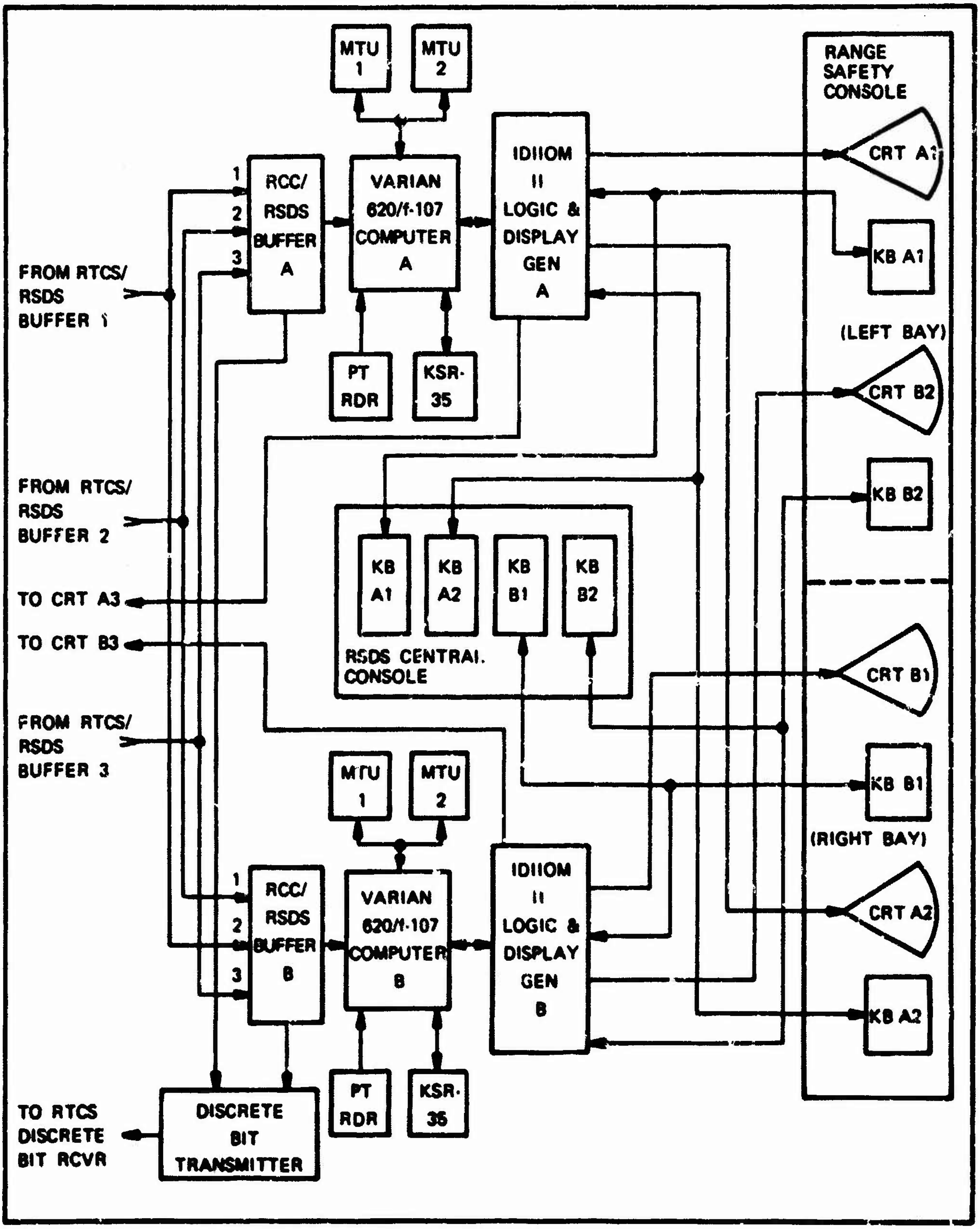


Figure 4-1B. Range Safety Display System Block Diagram

If the prime 3600 computer fails, the standby 3600 takes over, including outputting to both buffers 1 and 2; however, when this happens, debris footprint data capability is lost. The 3100 computer (A or B) outputs to the Varian computers through buffer 3. Data from the 3100 computer will be processed and displayed on the CRT's only if both 3600's fail. Data displayed will be theoretical impact point (IP), vertical plane present position, and selected alphanumerics. Details of these computers are covered in paragraph 3.6.1.3.

4.1.2 RTCS/RSDS Interface Buffer

The RTCS/RSDS interface buffer consists of three identical buffers. Each has a two-channel input that is CDC-3600 and 3100 compatible, a 512 twelve-bit word memory, and an output to both Varian computers. Buffers 1 and 2 are associated with 3600A and B with cross-over connection capability. Normally each buffer is associated with one Varian computer; however, a cross-over connection capability exists such that both Varian computers continue to receive all updated data even though one buffer has failed.

4.1.3 Varian 620/f-107 Computer

Each display system contains a Varian 620/f-107 computer. This computer has a 32 k, 16-bit word core memory with a cycle time of 750 nanoseconds. Standard features are direct memory access, real-time clock, power failure/restart, and priority interrupt. Optional features installed are: priority memory access for the IDIIOM, and automatic loader for rapid recovery. Peripheral equipment includes a 150-character-per-second paper tape reader, KSR-35 keyboard printer, and two magnetic tape units (MTU's) with controller. The MTU's are 7-track 556/800 b/in, 45-in/s units, vacuum buffered, and with read-after-write capability. One MTU is used in real-time for recording data received from the RTCS, while the other MTU contains an autoload tape for fast recovery. Data recorded on previous launches can be played back and an entire test simulated without the necessity of scheduling the RTCS.

4.1.4 IDIIOM II Display Generator

The display generator provides control and sequencing of the images on the CRT. Built-in circuits provide for the generation of vectors, circles, and 126 alphanumeric characters. Also provided is the ability to blink, dot, dot-dash, and provide solid line images on the display CRT's. The display generator is a special purpose computer with its own machine language sharing the 32,000 word memory of the Varian 620/f-107 computer.

4.1.5 Cathode-Ray Tube Displays (CRT)

The RSO console contains two RSO operating positions. Each position contains two 21-in CRT's (one from each display subsystem) and a 16-switch function keyboard for each CRT. With this configuration each RSO has control over the information desired to be observed via the function keyboard associated with that particular CRT.

4.1.6 Range Safety Console

Two identical operating positions are included in the console. Each position contains a CRT display and a function keyboard from each of the two independent display systems. Adjacent to each of the display bays is a communications console with a 10-channel network, 20 direct-line circuits, administrative telephone, and controls for the Range Safety TV display selection. The center bay of the console contains indicators and controls for common use by the two RSO's. Included are indicators for three countdown nets, two 5-inch TV monitors with channel select controls, a Z-time indicator, two interval timers, two RSO hold-fire switches, command function switches (arm, destruct, and special function), command transmitter control switches, and command antenna indicators.

4.2 AUXILIARY CAPABILITIES

4.2.1 Command/Control (Details are provided in paragraph 3.2.)

The command/control system provides the means for the RSO to terminate launch vehicle flight or initiate special functions for the Range User. When tracking information is received indicating that further flight should not be permitted, the RSO closes a switch on his console. This closure is sensed by the Range Instrumentation Control System (RICS) and relayed to each command/control station. At a preselected station, a signal which performs the required function is then transmitted to the vehicle.

4.2.2 Command/Control Panel

On-off switches and indicators are provided for the primary and backup Cape command/control transmitters. Lights indicate transmitter failure and automatic switchover to the standby transmitters.

The arm/fuel cutoff and destruct/propellant dispersion switches are recessed and protected by hinged metal covers. Red light indicators illuminate flashing (arm) or steady (destruct) when the command functions are sent.

A special function switch provides required selected control signals through the command transmitters.

4.2.3 RICS Panel

This panel contains on-off controls and indicators for all command/control transmitters. Green ready lights show when the transmitters are controlled by the Range Instrumentation Control System and a white light indicates which transmitter is active. Normally the transmitters are turned on and off at programmed times by a timer started by the first motion indicator.

Antenna status lights are provided for each command station to display antenna elevation with respect to vehicle position (red, less than 1°; amber, 1°–3°; green, greater than 3°).

4.2.4 Timing and Firing Control Panel

The timing functions include a visual display of automatic (manual backup) first motion elapsed time, Range countdown/plus count, a manual interval timer, and a timer activated by first motion indicating when flight termination action was sent.

A red "hold-fire" pushbutton switch/indicator provides the RSO with hold-fire capability.

A green "proceed" indicator illuminates when a hold is not in effect.

4.3 VERTICAL WIRE SKYSCREEN

The vertical wire skyscreen (VWS) consists of two vertical parallel wires, 12 inches apart, held in a 12 x 60 in adjustable frame. The wires are optically aligned (to avoid parallax) from a selected site pedestal through the launch site. The VWS site for each test is selected as close as possible to a point perpendicular to the flight azimuth and approximately 1 mile from the launch site. VWS are presently mounted on top of three Range Safety TV vans. The operator sights along the plane of the wires and gives a verbal account to the primary RSO of the vehicle's behavior throughout its vertical flight.

4.4 RANGE SAFETY CLOSED-CIRCUIT TV

Two 5-in TV monitors are located in the RSO console to provide real-time program and flight line displays of the launch vehicle to the RSO from prelaunch countdown throughout loss of optical coverage. One van-mounted TV camera is positioned perpendicular to the expected flight line trajectory for program display; the other van-mounted camera is positioned behind the launch vehicle and is pointed parallel to the intended flight path. Each van transmits the observed picture to the TV operations control center via microwave transmitters. The picture is then relayed by hardwire to the RSO console TV monitors (see figure 4-2).

4.5 PLOTTING BOARD DISPLAY SYSTEM (Backup system to the RSDS)

The plotting board display system comprises six 30 x 30-in, two-dimensional plotting boards located in front of a separate but fully equipped RSO console in the Range Safety area of the Range Control Center adjacent to the RSDS. Each board has two plotting pens plus two timing pens so that two different track loci can be displayed simultaneously. A tracking source indicator located above each plot board indicates both the tracking source and the type track (beacon or skin) being plotted by that board. Tracking data is presented on the plotting boards as vehicle present position and vacuum (theoretical) impact prediction displays. (Methods for selecting and presenting this data are discussed in paragraph 3.6.1.)

4.6 DATA DISPLAY (Additional information can be obtained from AFETR/Missile Flight Analysis, Patrick AFB, FL 32925.)

4.6.1 Radar Data

Radar data are displayed in X-Y and X-Z coordinates and represent the time correlated present position of the vehicle in flight. RTCS processed data, also

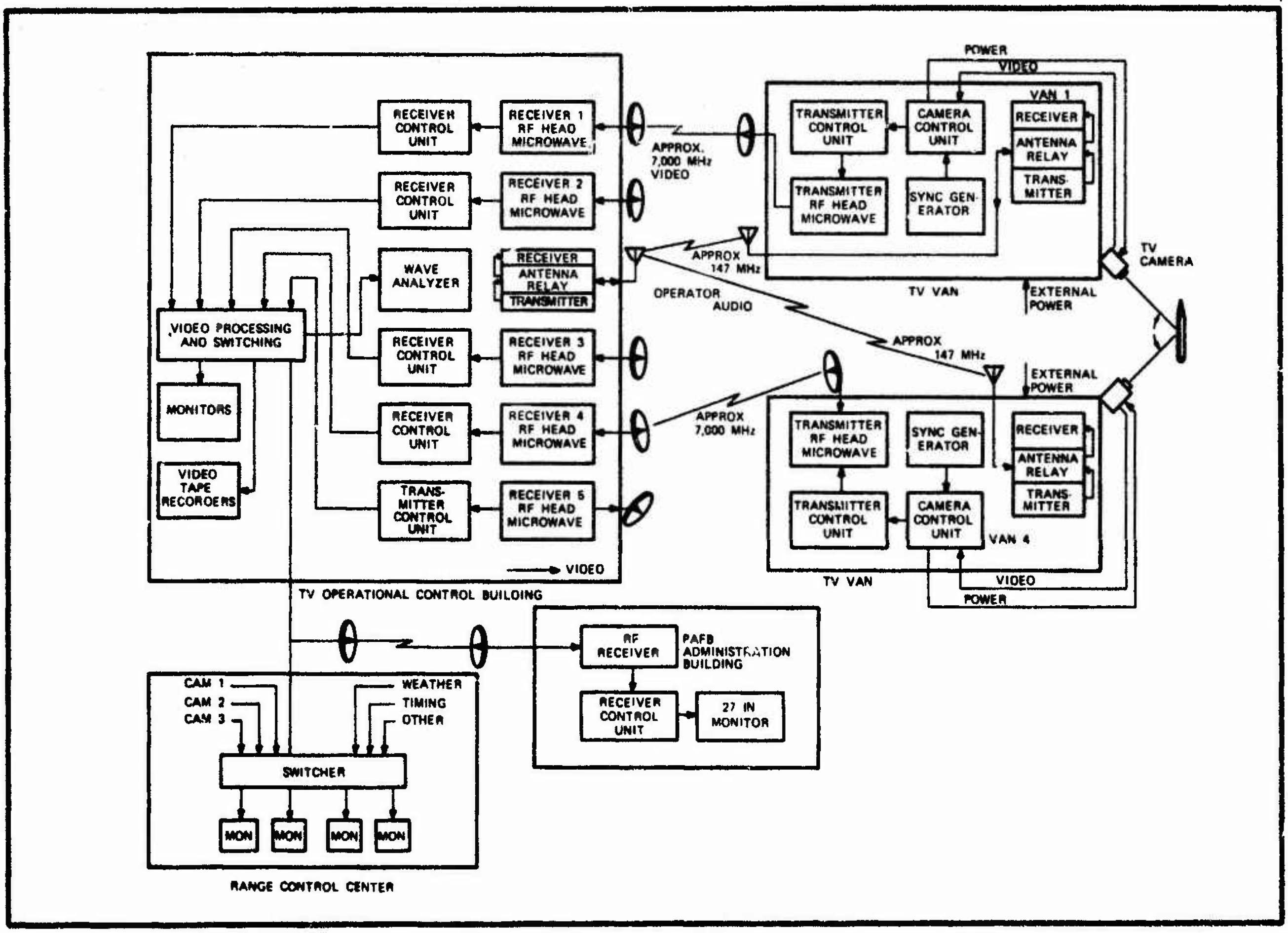


Figure 4-2. CCAFS Television System

displayed in X-Y coordinates, represent the real-time theoretical impact point of the vehicle.

Present position and impact point data are computed in the Real-Time Computer System (RTCS), using two computers which, by means of redundant equipment, can provide protection against component or module failure. Pulse radar tracking data and telemetered guidance information are received by the RTCS. Radar data are recorded on analog tape. These data can be used at a later time to simulate the mission for program and hardware checkout. All inputs are edited and smoothed. The best data source is selected and used to predict present position and primary impact point. The second best source is used to compute an alternate impact point. Primary and alternate impact points and present position information are send to the Range Safety area for presentation to the RSO.

4.6.2 Telemetry Data

A single telemetry display rack is located adjacent to the RSDS. Twenty-eight analog time-correlated channels are available to display real-time vehicle parameters (e.g., receiver agc levels, chamber pressures, guidance parameters) required by the RSO.

4.6.3 Launch Area Surveillance

A plotting board, displaying reported ships positions in the immediate launch or operating area adjacent to CCAFS, is operated by an RSO during operational testing. The reports are communicated to the plotting board operator from either an aerial observer or from the AN/SPS-35 radar operator. Viewing of the display is via closed-circuit TV to the TV monitors in the RSO console as well as other areas in the Range Control Center.

SECTION 5
SHIPS

The AFETR operates three instrumentation ships to provide data coverage in areas outside the limits of land stations. One of these ships, the USNS Redstone, operates primarily in the Atlantic in support of the Navy's Fleet Ballistic Missile Program. The other two, the USNS General H. H. Arnold and the USNS General Hoyt S. Vandenberg, presently provide support in the Pacific. Detailed characteristics of each are given in the following paragraphs and under the appropriate instrumentation category in previous paragraphs.

5.1 RANGE INSTRUMENTATION SHIP (RIS), USNS REDSTONE, T-AGM-20

The Range Instrumentation Ship, USNS Redstone (T-AGM-20) is configured to collect metric and telemetry data in remote areas. Additionally, equipment is available to provide ship's position and attitude, timing, data handling, communications, surface and upper-air meteorological data, and command/control which allows independent operation in the broad ocean areas of the Eastern Test Range.

The Redstone currently supports three basic types of missions:

(1) Functioning as the Downrang : Support Ship (DRSS), it supports ubmarine-launched ballistic missiles in the immediate postlaunch phase. In this role the ship support in conjunction with the Launch Area Support Ship (LASS), USNS Range Sentinel, and collects telemetry data from a ripple launch of up to four vehicles while located 100 to 150 miles from the launch point. When operating in the DRSS role, the Redstone can command the destruction of missiles which deviate from preplanned flight corridors.

(2) It provides terminal area ship support (TASS) for ballistic missile firings on the AFETR. In this mission it provides metric trajectory data, collects telemetry data from the reentry bodies, collects terminal area meteorological data, and calibrates the Missile Impact Location Systems (MILS) on the Range.

(3) The ship also provides support during the insertion and on-orbit phases of spacecraft operations. In this role it collects both metric and telemetric data and retransmits the information in real-time back to range control centers for further application.

Data gathered by the Redstone are normally shipped to Patrick AFB for processing, reduction, and distribution. Support activities (test planning, engineering, operational control, and logistic support) are also based at Patrick AFB.

The basic configuration of the Redstone is shown in figure 5-1.

The Redstone instrumentation complex is divided into 10 distinct but integrated systems as shown in figure 5-2. Each system is briefly described below. More detailed system descriptions can be found in sections 2 and 3.

5.1.1 Operations Control Center (OCC)

The OCC is the centralized control and monitor facility which provides integrated operations both aboard the ship and between ship and other stations. There are four major equipment items in this area: the Master Systems Console (MSC), the Designate Control Console (DCC), the DRSS Safety Officer Console (DSOC), and the recording and display equipment.

The MSC provides the displays, controls, and communications necessary to integrate and direct the functions of the instrumentation complex and to coordinate with other participating stations.

The DCC contains the status indicators, communications, and controls needed for selection of the master source on the synchro master acquisition

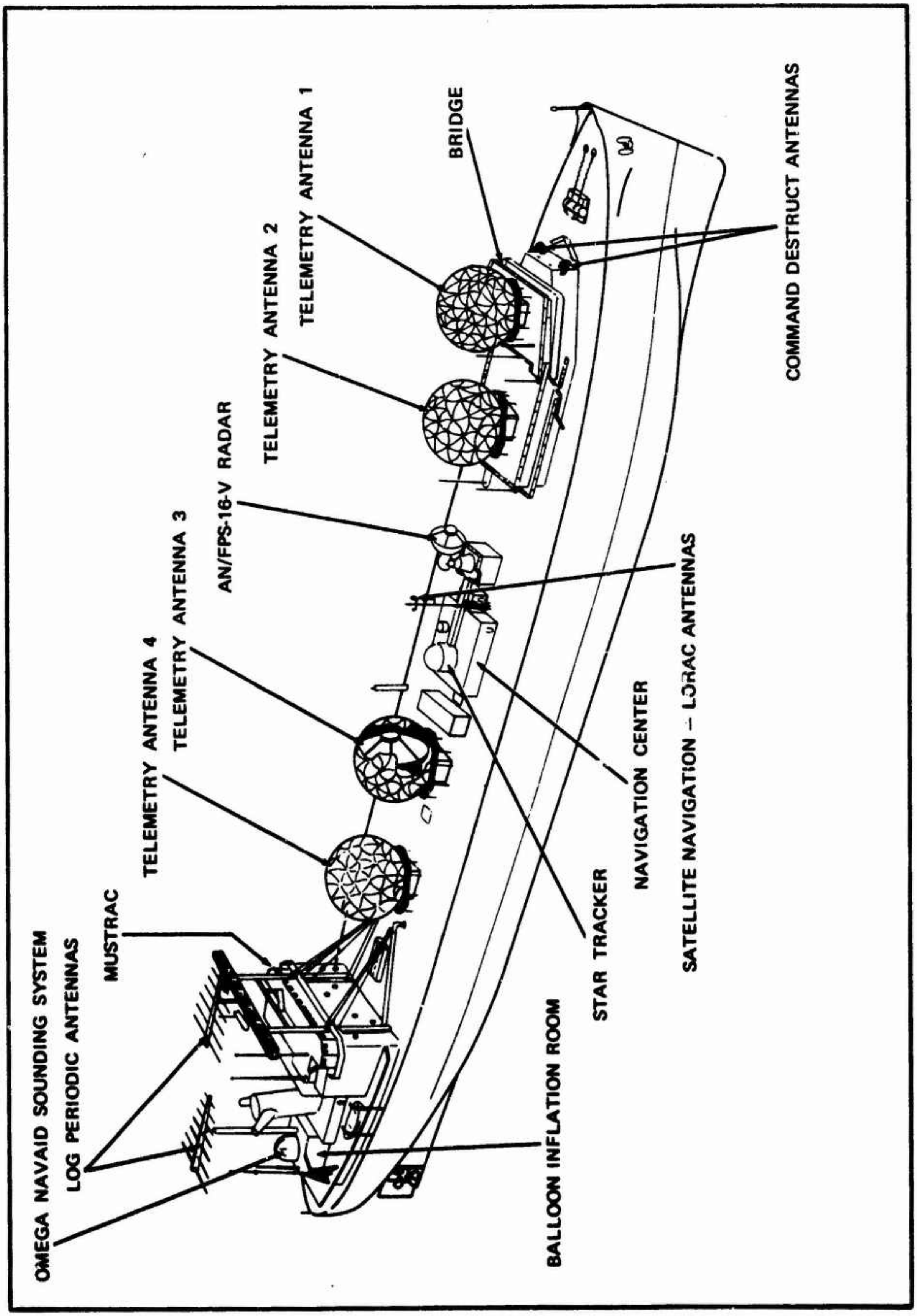


Figure 5-1. USNS Redstone Topside Arrangement

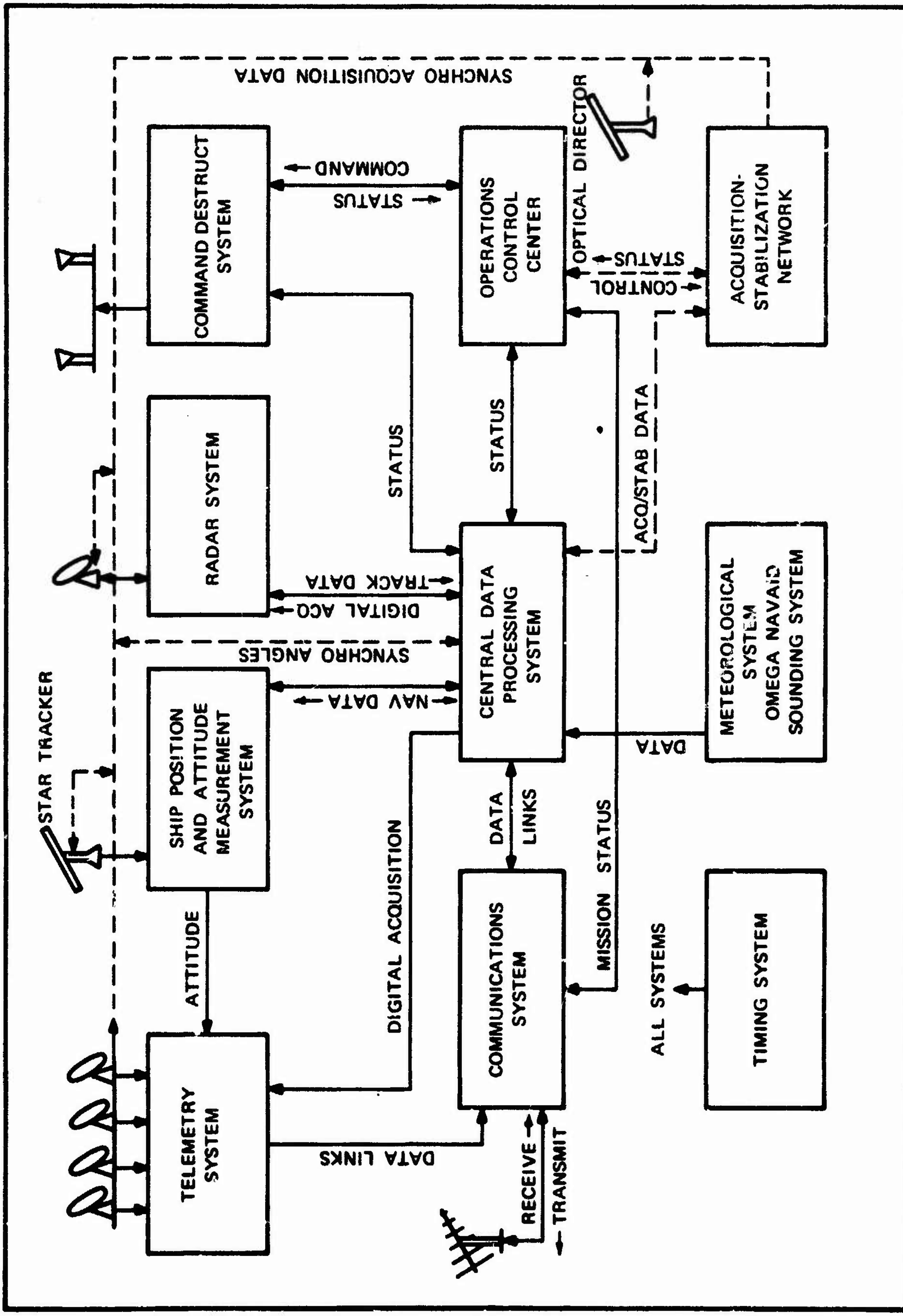


Figure 5-2. USNS Redstone Instrumentation Block Diagram

bus, and for selection of the radar designate source when the radar is in the digital slave mode.

The DSOC controls range safety command destruct functions on the ship. The console furnishes command and control status and data displays, and contains necessary operational and communications controls.

The 120-channel event recorder displays and records selected events from the radar and telemetry systems. Two dual-arm 30-in x 30-in vertical plotting boards display target position and predicted impact points in cartesian coordinates.

5.1.2 Tracking Radar System

The Redstone's precision tracking radar is an AN/FPS-16 type modified for shipboard use by the addition of on-mount rate gyros and a hydrostatic bearing compensated for horizontal thrust components. This radar is capable of high accuracy stabilized tracking of high-speed targets using target-borne beacons and is also capable of skin tracking.

To meet Range needs for an improved skin tracking capability, an alternate transmitter, AN/FPS-26 type, is selectable for use in the radar system. Both transmitters use the same antenna and waveguide and the desired transmitter output is routed by a waveguide switch. Further details are provided in paragraph 2.1.4.

5.1.3 Telemetry System

The Redstone telemetry system can detect, track, receive, record, separate, and decommutate telemetry data. Processed data may be recorded, displayed, or retransmitted in real-time or post-mission.

The system includes four completely independent 17-ft diameter autotracking antennas, each enclosed in a protective radome. The antennas provide 38 dB gain over the 2200 to 2300-MHz frequency range.

The receive and record subsystems include 24 data receivers, five 14-track magnetic tape recorders, and the necessary ancillary equipment to allow receipt and recording of both pre- and post-detection telemetry signals.

The data separation and display subsystem includes two time division multiplex (TDM) stations, tunable and fixed discriminators, and several types of display units.

The retransmission subsystem consists of a signal processor and conditioner (SPAC) to process and output digital data to the communications system and video retransmission equipment for retransmitting recorded telemetry video data over vhf links to aircraft for quick-look data.

Further details are provided in paragraph 2.2.20.

5.1.4 Ship Position and Attitude Measurement System (SPAMS)

The SPAMS provides continuous and accurate data of ship attitude (roll and pitch relative to the local vertical, and heading relative to north), velocity (inertial components north, east, and vertical), and position (latitude and longitude). The system is comprised of a number of individual subsystems and equipment integrated to provide data for stabilization of shipboard antenna systems and for conversion of angle information from deck-referenced coordinates to Earth-referenced coordinates. The system also provides for ship's velocity measurement, and for monitoring the flexure angles between the bedplate caused by the nonrigidity of the ship.

5.1.5 Command Destruct System (CDS)

The CDS provides the Redstone with the capability of commanding the destruction of missiles in flight. This destruct capability is used only when the ship is operating as the DRSS and in conjunction with the LASS.

Upon receipt of a destruct request from the LASS, the onboard DRSS Safety Officer (DSO) initiates proper commands to the CDS to generate and transmit coded arm and destruct signals to the missile. The CDS is a redundant 10-kW uhf system with a capability for automatic or manual switch-over to on-line standby equipment upon failure detection. Further details are provided in paragraph 3.2.2.

5.1.6 Central Data Processing System (CDPS)

The CDPS receives ship's position and attitude data, timing signals, control and status signals, radar antenna pedestal flexure data, target acquisition information, and real-time radar tracking data. It processes the received information to provide data for antenna pointing, ship's position and attitude, trajectory data recording and display, plotting board tracking, target acquisition, command and control functions, status display, and real-time transmission.

The CDPS consists of a Univac 1230 digital computer with associated peripheral equipment and buffers which interface the computer with instrumentation complex equipment. The Univac 1230 (modified CP-642B) is a medium scale, general purpose computer with a random access memory of 32,608 thirty-bit words, 16 input and 16 output channels for information transfer, and cycle times of 2 μs. Peripheral equipment includes one 2-deck and one 4-deck magnetic tape unit, input-output console, teletypewriter unit, high-speed printer, raw data recorder, and interface buffers to instrumentation equipment. Further details are provided in paragraph 3.6.3.

5.1.7 Timing System

The timing system generates and distributes the standard frequencies, time codes, and repetition rates required for precise synchronization, calibration, and time identification of instrumentation complex functions and data.

The system is similar to other standard Range timing installations but incorporates certain design features to improve accuracy and reliability. Frequency and time generation are redundant with (1) manual on-line selection and (2) electronic, transient-free failure alarms and switchovers. Rechargeable emergency batteries and electronic power switchover circuits permit operation of essential system functions for up to 8 hours without loss of synchronization in the event of primary power failure. Features include a rubidium-vapor primary frequency standard, correlated crystal secondary frequency standard, cesium beam frequency standard as master clock, provision for both vlf and WWV radio broadcast synchronization, compensation for the ship's radial velocity during synchronization, and integral patch panel for output distribution. See paragraph 3.3.9.

5.1.8 Acquisition/Stabilization Network (ASN)

The ASN provides target synchro acquisition and antenna stabilization signals required to interconnect, position, and stabilize certain tracking and remotely controlled directional antennas on the ship. The system may be controlled centrally from the OCC or locally at individual system consoles. The prime synchro designation source may be either the CDPS computer, radar antenna, optical director, or any of the telemetry antennas. Antennas using synchro data may then be slaved to the selected prime designation source for acquisition purposes. The star tracker may also be slaved to the prime designation source.

When lock-on is accomplished and automatic tracking begins, on-track signals are transmitted to the pertinent consoles via the on-track subnetwork. The designate controller in the OCC receives the on-track data from the designate sources and assigns the master antenna for the synchro master acquisition bus.

The system has an optical acquisition aid and four principal subnetworks: ship's heading, on-track, stabilization, and acquisition.

5.1.9 Meteorological System

The Redstone, like other AFETR stations, collects and records weather data to determine its effect on a given mission and to predict weather conditions for future scheduling and planning. Both surface weather data (wind speed and direction, pressures, etc) and high altitude data are collected. See paragraph 2.5.

5.1.10 Communications System

The communications system includes radio transmitters and receivers for long and short-haul communications in the hf, vhf, and uhf bands. Also included in the radio subsystem are a cryptographic facility, teletype, and high-speed digital data link facilities. An interphone subsystem provides for inter- and intraship voice traffic during operational support. A dial telephone subsystem is used for administrative support and an entertain-

ment subsystem receives and distributes television and radio broadcasts to personnel spaces on the ship. See paragraph 3.1.

5.1.11 Miscellaneous Equipment

Cine and ballistic cameras can be installed to acquire optical documentary, engineering, spatial, and radiometric data to support Range Users.

Acoustic velocimeter, bathythermograph, and T-0 recorders are used to determine the velocity of sound at varying depths and record event times for underwater sound signals.

A transponder (beacon) and radio homing devices are installed to provide navigation assistance to Range aircraft participating in mission support.

MUSTRAC is a multiple target steerable telemetry tracking system which has been placed aboard the Redstone for engineering evaluation. The multiple beam system can simultaneously search, acquire, and track up to four independent sources located within a 50° cone. The system uses a pedestal positioner for locating the array face in such a manner that the 50° cone of coverage can be optimally used. The technique employed is not electronic steering but one of selection of the various beams formed by a beam-forming network (lenses). The selection commands are generated in a small general-purpose computer which generates a scan for the search mode, performs acquisition functions, and processes the tracking error signals. The MUSTRAC antenna has an aperture of 7 ft and uses transistorized preamplifiers in the receiving subsystem.

5.2 ADVANCED RANGE INSTRUMENTATION SHIPS (ARIS), USNS ARNOLD, T-AGM-9, and USNS VANDENBERG, T-AGM-10

The USNS General H. H. Arnold and the USNS General Hoyt S. Vandenberg are the two Advanced Range Instrumentation Ships (ARIS) which are designed to gather precision data on missile reentry bodies and penetration aids; each ship carries multiple high performance radars, broadband telemetry, and radiometric and optical instrumentation. Additional equipment for navigation/stabilization, meteorology, data handling, timing, control, communications, and marine support allows independent operation in remote areas of both the Eastern Test Range and the Western Test Range.

Both ships are converted C-4 cargo class ships which were formerly used as troop ships. Figure 5-3 shows the ARIS inboard profile. The primary mission of the ship instrumentation is to gather scientific measurement data associated with the midcourse and reentry phases of ballistic missile flight. These data can be divided into two principal regions: those which pertain to exoatmospheric flight and those which are endoatmospheric. Of specific interest are those target properties and characteristics such as size, shape, mass, and precision motion which produce certain distinct signatures or modulations on a radar signal.

In addition to the primary purpose of the ARIS system as a tool for gathering data on missile reentry bodies, the ships constitute a flexible expansion of the missile test ranges beyond the coverage capabilities of land-based instrumentation.

ARIS instrumentation is divided into nine major subsystems as shown in figure 5-4. Each subsystem and its capability is briefly described below. More detailed system descriptions can be found in sections 2 and 3.

5.2.1 Operations Control Center (OCC)

The OCC is the centralized control facility which provides integrated operations both aboard ship and between the ship and other stations. There are two major equipment items in this area: the master control console (MCC) and the designate control console (DCC).

The MCC displays ship's heading, speed, and position from the navigation subsystem; instrumentation status from all subsystems; and radar boresight television. The master countdown clock and two intercom stations are also provided.

The DCC provides status displays for all systems which can be selected as MASTER on the acquisition buses, including radar antenna, telemetry, computer, star tracker, and the IFLOT. Switches are provided to allow selection of the desired MASTER system. The on-track or off-track condition of the radars and telemetry is displayed. A countdown clock and communications panel are also provided.

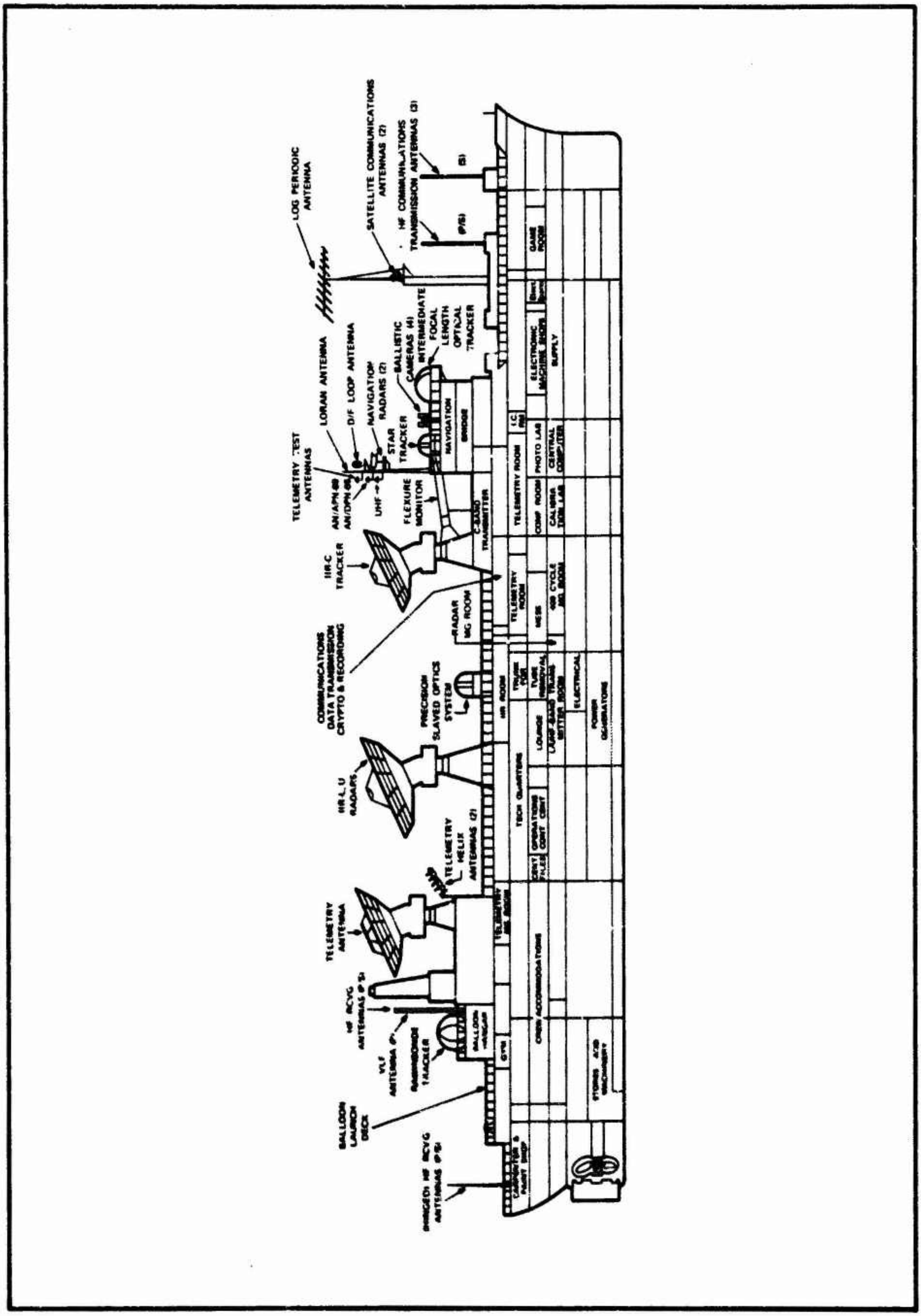


Figure 5-3. ARIS Inboard Profile

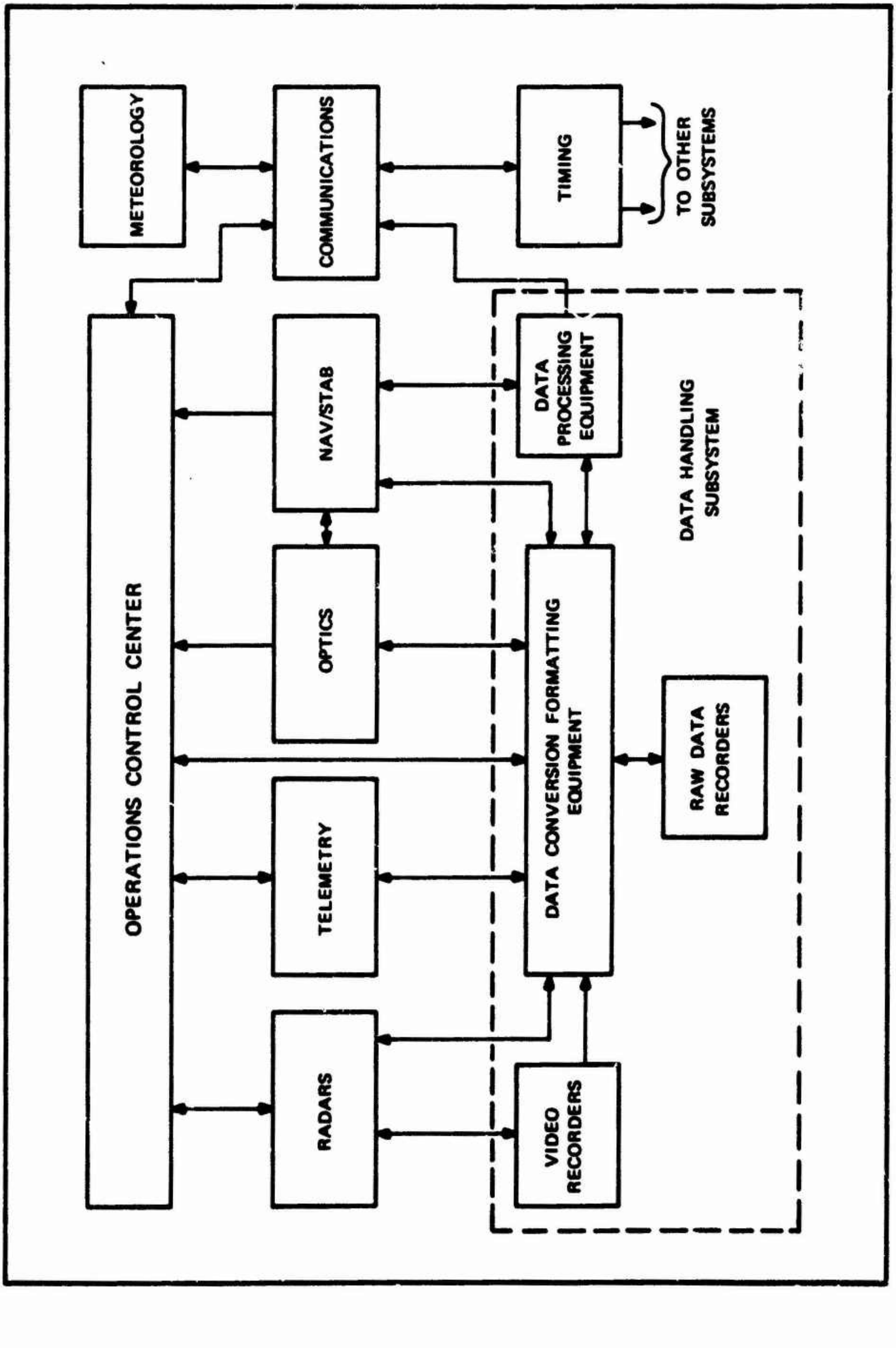


Figure 5-4. ARIS System Block Diagram

5.2.2 Radar

The ARIS radars are powerful pencil-beam subsystems utilizing pulse compression circuits and parametric amplifiers for high sensitivity.

The IIR-C radar provides metric (position) and signature (cross-section) data on a primary target plus all secondary targets within the beamwidth and range cell. It is capable of skin or beacon track. The system features dual transmitters for interlaced horizontal/vertical transmission, pulse compression, and dual receiving channels with video outputs for recording. Metric data is obtained from the vertical channel while signature data is obtained at both polarizations.

The IIR-L radar aboard ARIS provides metric and signature data on a primary target plus all secondary targets within the beamwidth and range cell. It has a single transmitter for horizontally polarized transmissions, pulse compression, and video output for recording. Since this radar is an independent tracker, two widely separated targets can be tracked simultaneously by each radar. The uhf coherent (IIR-U) radar shares the 40-ft antenna with the IIR-L radar. The uhf radar provides vertically polarized signature data on all targets within the beamwidth and range cell and wake data in 27 sample positions. It has a single transmitter, pulse compression, and video and phase data output for recording. Target designation data for the radars can be obtained from the central computer, telemetry, optics, and radar console handwheels. Further details are provided in paragraph 2.1.3.

5.2.3 Telemetry

The primary telemetry equipment provides designate data to the radars and collects telemetry data in a variety of frequency bands. The prime antenna is a 30-ft autotracking parabolic dish with a broadband 225 to 4000-MHz feed. The antenna mount and servo system are identical to those used for the radars. The TRKI-12 receive/record system provides reception in the following bands: 216-260 MHz, 285-410 MHz, 920-965 MHz, and 2185-2310 MHz. Wideband recorders are used for pre- and postdetection recording/playback.

Fm discriminators for all IRIG channels and a stored program PCM/PAM/PDM decommutator are available for signal separation. Display units include digital bar-graph, direct write recorders, and oscillographic recorders. The data retransmission capability provides real-time digital data up to 2,400 b/s to compatible ETR stations.

A Whitelaw telemetry system is used to augment primary telemetry equipment. The system uses several antennas including a 40-in dish mounted atop the 30-ft telemetry antenna, multiple receivers to cover the entire frequency range, and wideband recorders for pre- and postdetection recording/playback. No data retransmission is available with this system.

Further details are provided in paragraph 2.2.2.1.

5.2.4 Optics

The ARIS optical capability consists of boresight cameras, ballistic camera arrays, cinespectrograph, radiometry, image surveillance, and high resolution/long focal length photography. Optical equipment is distributed between several pedestals: radar and telemetry tracking pedestals, manual IFLOT pedestals, and a precision slaved optics pedestal.

The slaved optics system can record cineradiometry in two bands (visible and near infrared), spectroscopy in three bands (near ultraviolet, visible, and near infrared), and shape/size imagery in the visual band. The cineradiometers and cinespectrographs have day and nighttime capability; the ballistic cameras and ballistic spectrographs have only a nighttime capability; and the shape/size imaging system has a full daytime and partial nighttime ("hot" body only) capability.

The system also includes an optical calibration system consisting of a collimator, a calibrated tungsten lamp source, a mercury vapor spectral source, a black-body source, and a system of selectable apertures and neutral density filters capable of providing complete intensity and spectral calibrations. See paragraph 2.3.

5.2.5 Navigation/Stabilization

This subsystem is composed of a Mk 3 Mod 8 Ship's Inertial Navigation System (SINS), a Mk-19 gyrocompass, a sonar beacon ranging system, an electromagnetic log, a star tracker, Loran equipment, Decca equipment, satellite navigation receiver, and two radar beacons.

The 1206 computer uses inputs from the above equipment to derive ship's position and heading and for tracking system orientation.

SINS outputs are latitude, longitude, roll, pitch, and heading. Attitude data are used to remove ship's motion from the computer designate data and to provide a reference for transformation of radar deck elevation and bearing to a stable local vertical coordinate system.

For precision navigating, the SINS is used as a means of interpolating ship's position and heading between star tracker, satellite position, or sonar fixes. Prior to support of a mission in a broad ocean area, a pattern of two or three sonar beacons may be sown. Geodetic locations of the beacons are established by obtaining ship position fixes using the star tracker or satellite navigation receiver while simultaneously recording slant ranges to the sonar beacons. Two radar beacons are included in the navigation subsystem: AN/APN-69 and AN/DPN-66. These beacons are aircraft/ship navigation aids.

5.2.6 Data Handling

The data handling subsystem provides a capability for processing 33 million bits per second. The data handling subsystem also provides:

1. Conversion, formatting, and recording of metric and signature data.
2. Computer support for target designation, navigation, calibration, and checkout.

Three major equipment groups make up the data handling subsystem.

1. The first, data processing equipment, includes the central computers, peripheral equipment, and related software.
2. Video recording equipment provides redundant recording of all radar signature data and includes 2-in. magnetic tape units with associated electronics and buffers. Tape copies can also be made aboard ship.
3. Data conversion equipment serves an interface for the processing and recording function by providing two-way conversions between digital analog data for recording and computer entry, routing data between subsystems for the tracking radars, and recording all prime target metric and signature data with SINS attitude and other reference data.

IIR-C radar data on the Vandenberg are recorded on 1-in tape and then transcribed to ½-in tape in IBM format. The Arnold's IIR-C radar data are recorded directly in IBM format on ½-in tape. IIR-L radar data, on both ships, are recorded on ½-in tape directly in IBM format. See paragraph 3.6.4.

5.2.7 Timing

The timing subsystem provides accurate time and/or reference signals to all subsystems to permit correlation of independent events both internal and external to the ship. The cesium standard is stable to within 1 part in 10^{11} per day and maintains time correlation between the ship and Cape Canaveral to within ±0.5 ms at distances up to 10,000 miles. Receiver/comparators in the system provide for synchronization of the ship's timing system with WWV, WWVH (Hawaii), NBA (Balboa, Panama), GBR (Rugby, England), or WWVL (Boulder, Colorado). The system is capable of providing an output of 23 digital codes, 39 pulse rates, 39 mixed codes, and 7 sine waves in standard IRIG format.

See paragraph 3.3.10.

5.2.8 Meteorology

Surface and high altitude meteorological data are gathered by both ARIS ships to furnish accurate and timely weather information needed to schedule tests and analyze missile performance data. All meteorological data are transmitted to Patrick AFB via teletype.

See paragraph 2.5.

5.2.9 Communications

The communications subsystem provides for internal and external transmission and reception of voice, teletype, and data. Internal voice communications include a direct-dial Electronic Private Automatic Branch Exchange (EPABX) system with

trunks for shore access; an intercommunications system with access from any instrumentation area; a sound-power telephone system used in instrumentation maintenance and as a limited backup system to the intercommunication or EPABX systems in some areas; and a PA system for announcements to all instrumentation areas.

External communications provide ship/shore, ship/ship, and ship/aircraft exchange of information and consists of an antenna system; vhf/lf/hf receivers; hf transmitters; vhf/uhf transceivers; and tone, teletype, and cryptographic instrumentation. Receive, transmit, and audio patching facilities are included to permit interchange of equipment and antennas. Voice, teletype, and data are the types of information exchanged by the radio link. All traffic is controlled by the communications control console located in the communications control center.

See paragraph 3.1.

TABLE 5-1. RANGE INSTRUMENTATION SHIPS CHARACTERISTICS

System	T-AGM 9 Gen H. H. Arnold	T-AGM 10 Gen H. S. Vandenberg	T-AGM 20 Redstone
Ship			
Primary Mission	Signature Collection	Signature Collection	Downrange Support-Poseidon
Hull type	C4-S-A1	C4-S-A1	T2-SE-A2 (Jumbo)
Displacement	17,120 tons	17,120 tons	19,770 tons
Length	522 feet	522 feet	596 feet
Beam	72 feet	72 feet	75 feet
Operating draft (approx)	26 feet	26 feet	25 feet
Ships crew	84	84	74
Instrumentation crew	61	61	42
Nominal speed	13.5 knots	13.5 knots	12 knots
Maximum days at sea	60	60	60
Home port	Honolulu	Honolulu	Port Canaveral
Ship Navig. Equip.			
Master gyrocompass	MK 14 MOD 1	MK 14 MOD 1	MK 14 MOD 1
Navigational radar	RCA NIC 75	RCA NIC 75	Raytheon 1404A, 1450
Loran	A/C Sperry Mod 1	A/C Sperry Mod 1	Mackay 4202B
Radio direction finder	Mackay 4004A	Mackay 4004A	Mackay 4004A
Fathometer	Raytheon DE-714/715	Submarine Signal CBM-896	Raytheon DE-714/715
Facsimile	None	None	Precision Marine CDDI 519M(T)
Ship Radio			
Primary radio	Mackay MRU-25A	Mackay MRU-25A	Mackay MRU-21/22AP
Radiotelephone	Vhf Raytheon 124ME28A	Vhf Collins 17L7 Vhf Raytheon 124ME28A	Vhf Raytheon 124ME28 Hf Mackay MRU-13

TABLE 5-1. RANGE INSTRUMENTATION SHIPS CHARACTERISTICS (Continued)

System	T-AGM 9 Gen H. H. Arnold	T-AGM 10 Gen H. S. Vandenberg	T-AGM 20 Redstone
Metric/Signature Radar			
Antennas	IIR-C, 30-ft dish IIR-L, 40-ft dish	IIR-C, 30-ft dish IIR-L, 40-ft dish	AN/FPS-16 (V) system 16-ft dish
Parameters	IIR-C (5400-5900 MHz) Dual polarization 30 microsec/1MW chirped pulse for skin track PRF-320* IIR-L (1280 MHz) Horizontal polarization 30 microsec/8MW chirped pulse PRF-160 Uhf coherent (435 MHz) Vertical polarization 30 microsec and 300 microsec/5 MW PRF-160, 960-1120, 1280, 1440, 1600 IIR-C and IIR-L have full autotrack, uhf has range track only *Two transmitters, each transmitting 160 p/s, are used to illuminate targets. One transmits linear-horizontally polarized signals, the other linear-vertically polarized. The transmitter signals are interlaced and use the same antenna.	(5400–5900 MHz) Dual polarization 30 microsec/1MW chirped pulse for skin track PRF-320* IIR-L (1280 MHz) Horizontal polarization 30 microsec/8 MW chirped pulse PRF-160 Uhf coherent (435 MHz) Vertical polarization 30 microsec and 300 microsec/5 MW PRF-160, 960-1120, 1280, 1440, 1600 IIR-C and IIR-L have full autotrack, uhf has range track only	FPS-16/FPS-26 transmitter 1 μs/1MW 1, 10 microsec/2.5MW PRF-160

TABLE 5-1. RANGE INSTRUMENTATION SHIPS CHARACTERISTICS (Continued)

System	T-AGM 9 General H. H. Arnold	T-AGM 10 Gen H. S. Vandenberg	T-AGM 20 Redstone
Telemetry System			
Antennas	30-ft dish (225-4000 MHz) 1-225/2300-3000 MHz	30-ft dish (225-4000 MHz) 1-225/2300-3000 MHz	Four 17-ft dish (2200-2300 MHz) 1 MUSTRAC
Receivers	12-SG5000B	12-SG5000B	24-Space General (300-400 MHz)
Wideband Recorders	2-Ampex FR-1400, Bell & Howell 4-VR-3700B	2-Ampex FR-1400, Bell & Howell 4-VR-3700B	5-Ampex (14-track)
Data Separation	23-FM/FM Discrim TDM-II (D/A Converter Monitor 2119, A/C Converter Monitor 2239) Signal Programming & Condition Equip.	18-FM/FM Discrim TDM-II (A/D Converter Monitor 2119, A/D Converter Monitor 2239) Signal Programming & Conditioning Equip.	30-FM/FM Discrim Bendix TDA-410/430 SPAC, TDM-1A, TDM-1 A/D Converter, D/A Converters
Data Record & Display	Four 8-channel pen Brush MK-200 5-Oscillographs Honeywell 1612 Digital Bar-graph, Monitor 2321	Four 8-channel pen 3-Oscillographs Honeywell 1612 Digital Bar-graph, Monitor 2321	Seven 8-channel pen 4-Oscillographs CEC 5-133 Digital Bar-graph
Predetection Record Capability	Yes w/Ampex or CEC	Yes w/Ampex	Yes (5WO-TRKI-12
Control Data Proc. System			
Computer	Univac 1206, Univac 1230 & 642B	Univac 1206, Univac 1230 & 642B	Univac 1230
Display in Computer Room	2-High Speed Printer, 2 Event Recorders	2-High Speed Printer, 2-Event (100ch)	High Speed Printer, X-Y Plotter
Data Transmission Equip.	3-TTY Interface (100 w/min)	3-TTY Interface (100 w/min)	2-TTY Interface (100 w/min)

TABLE 5-1. RANGE INSTRUMENTATION SHIPS CHARACTERISTICS (Continued)

System	T-AGM 9 Gen. H. H. Arnold	T-AGM-10 Gen. H. S. Vandenberg	T-AGM 20 Redstone
Control Data Proc. System (cont'd)			
Other Equipment	Raw Data Recorder, RVRPE, LVRS	Raw Data Recorder, RVRPE, LVRS	Raw Data Recorder Data Transmission (1230/Modem)
Timing System			
Timing Format	IRIG A,B,H,D,E,F1 thru 19, G1-G6, XR3	IRIG A,B,H,D,E,F1 thru 19, G1-G6, XR3	IRIG A thru H CDP Code
Pulse Rate	28 pulse rates	28 pulse rates	1,2,10,20,40,100 p/s, 1k, 10k, 2, 10 p/min
Communications System			
Ship to shore (hf)	Two 10kW Transmitters, Collins 204C1 (4-25MHz) Two 2.5kW Transmitters, Collins 204F1 (2-30MHz) 6-Receivers, Collins (1-50E6, 5-651F1) 2-Receivers, R390	Two 10kW Transmitters, Collins 204C1 (4-25MHz) Two 2.5kW Transmitters, Collins 204F1 (2-30MHz) 6-Receivers, Collins (1-50E-7 5-651F1) 2-Receivers, R390	Six 10kW Transmitters, TMC TSTE-10k 7-Receivers, TMC DDRR-506 3-Receivers, Collins 51S-1F
Ship to air (vhf)	20 W-VF101 Transceiver	20 W-VF 101 Transceiver	Two 20 W Transceivers
Ship to air (uhf)	100 W Transceiver, AN/GRC-27	100 W Transceiver, AN/GRC-27	Three 100 W Transceivers, AN/URC-9
Tactical satellite (uhf)	1000 W Transceiver, AN/ARC-146	1000 W Transceiver, AN/ARC-146	3-Telemetry Retransmission Sys uhf
Crypto	Yes	Yes	Yes
Internal communications	Dial Telephone, Interphone	Dial Telephone, Interphone	Dial Telephone, Interphone
Teletype	60-100 w/min (13 ASR, 9 KSR)	60-100 w/min (13 ASR, 8 KSR)	60-100 w/min (7 ASR, 8 KSR)

TABLE 5-1. RANGE INSTRUMENTATION SHIPS CHARACTERISTICS (Continued)

System	T-AGM 9 Gen. H. H. Arnold	T-AGM 10 Gen. H. S. Vandenberg	T-AGM 20 Redstone
Communications System (cont'd)			
Multiplex	AN/FGC-60 (V)	AN/FGC-60 (V)	2-AN/FGC-60
Other	Vlf Receiver, SP-600 4-Hf Data Modem (AN/USC-12, 12A 2-FEDAC AN/USA-29	Data Modem AN/USC-12 2-Hf Data Modems (AN/USC-12C 2-FEDAC AN/USA-29) Vlf Receiver SP-600	2-FEDAC AN/USA-29 4-High Speed Modems AN/USC-12A (2400 b/s)
Operations Control Center			
Console	SM, MCC & DCC	SM, MCC & DCC	SM, Des Control, Flight Safety
Display (NOTE: (*) means CDP Controlled)	Two X-Y Plotters (*)	Two X-Y Plotters (*)	Two X-Y Plotters (*)
Recorder	PPI (RCA NIC 75)	PPI (RCA NIC 75)	
Ship's Position & Attitude Measurement System (Navig.)			
SINS	MK 3 Mod 8	MK 3 Mod 8	MK 3 Mod 5
Star tracker	Yes	Yes	Yes integral w/SINS
Gyrocompass	MK 19 Mod 3	MK 19 Mod 3	MK 19 Mod 3
Dead reckoning equipment	None	None	None
Radio navigation equipment	Loran C, AN/SRN-9	Loran C, AN/SRN-9	Lorac C, AN/SRN-9, AN/BRN-3 provisions for Loran C
EM log	Yes	Yes	Yes
Other	Depth Sounder AN/UQN-1, ASPS Unattended Scoring System	Depth Sounder AN/UQN-1, ASPS	Omega Nav. System Depth Sounder AN/UQN-1, ASPS Doppler Speed Log

TABLE 5-1. RANGE INSTRUMENTATION SHIPS CHARACTERISTICS (Continued)

System	T-AGM 9 Gen. H. H. Arnold	T-AGM 10 Gen. H. S. Vandenberg	T-AGM 20 Redstone
Command Control			
Transmitter	None	None	Dual 100 W transmitters (406-450 MHz) dual 10 kW PA
Antenna	None	None	Dual Helix (Command Destruct)
Other			
Air data pickup	None	None	Yes
Radiosonde	GMD-4 (AN/AMQ-9)	GMD-4 (AN/AMQ-9)	Omega Navaid Sounding System
Optics	Slaved Optics (50 in. Lens) Optical Director (IFLOT) Ballistic Cameras Precision Optical Tracker	Slaved Optics (50 in. Lens) Optical Director (IFLOT) Ballistic Cameras Precision Optical Tracker	Optical Director MK-51

SECTION 6
AIRCRAFT

Instrumented aircraft presently available at the AFETR perform electronic and optical data acquisition and processing in support of DOD and NASA requirements. There are two models of the C-135 type aircraft used as airborne platforms. These are eight Advanced Range Instrumentation Aircraft (ARIA) and one Terminal Radiation Program Aircraft (TRAP).

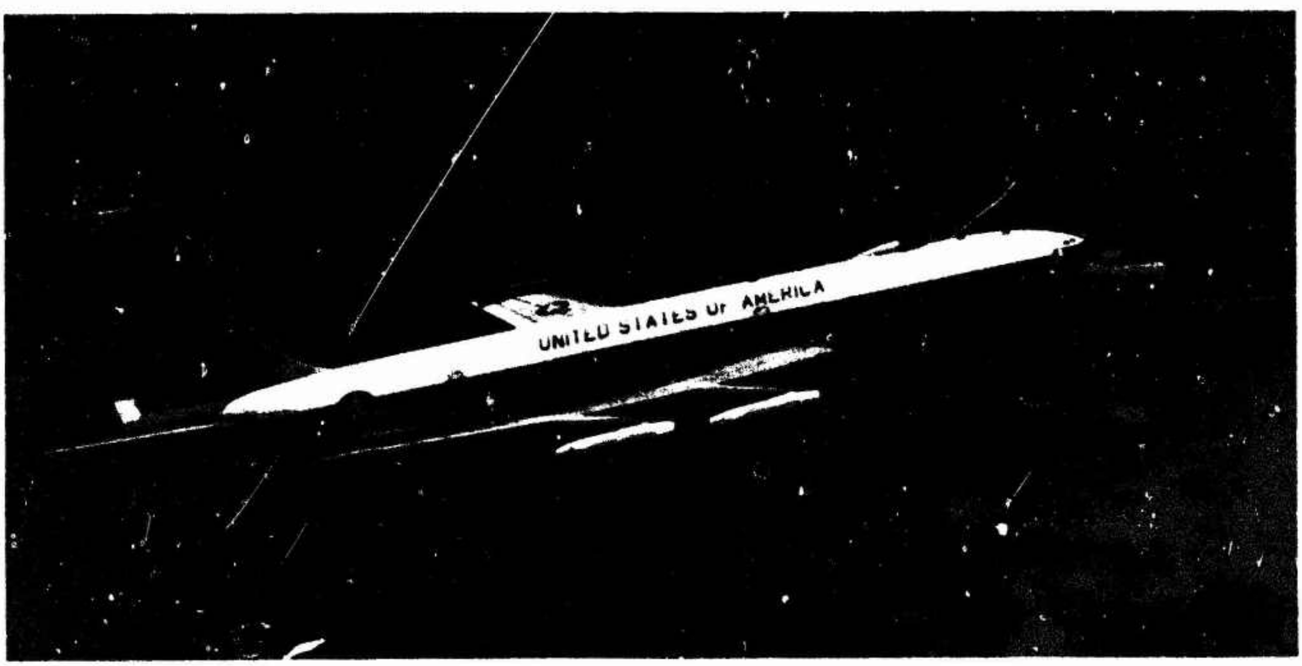
The ARIA can receive, record, and retransmit voice and telemetry signals from any moving or stationary source at almost any location. The aircraft can provide up to 3½ hours of continuous real-time telemetry relay.

The TRAP aircraft is equally flexible in the acquisition of optical data. While the system is primarily used to cover reentry vehicles, it can also monitor aerodynamic performance and signature data during the powered flight of both air and surface-launched missiles. Both ARIA and TRAP can be configured to meet specific user requirements, and inquiries from program managers are welcome.

The aircraft are presently assigned to the 4950th Test Wing, Aeronautical Systems Division (ASD), Wright-Patterson AFB, Ohio 45433. Aircraft support for missions involving AFETR as the lead range should be requested from AFETR/DO. The aircraft will continue to support the worldwide requirements of the national ranges and NASA. Nominal flight performance is listed in table 6-1 and standardized navigational capabilities are listed in table 6-2.

6.1 ADVANCED RANGE INSTRUMENTATION AIRCRAFT (ARIA)

The ARIA are airborne telemetry receive/record including strip-out and retransmission, (up and down) stations. Each is equipped with the following instrumentation:



ARIA AIRCRAFT

INSTRUMENTATION CHARACTERISTICS

Antenna tracking . 7-ft parabolic dish equipped for Unified S-Band (USB), uhf (2200-2300 MHz, 750-1540 MHz), and vhf (136-400 MHz) polarization diversity.

Antenna wing probes . . 2 each for hf communications

Antenna . . Trailing wire for hf communications

Receivers . . . . . Uhf/vhf tracking, four-dual (sum difference)

Receivers . . . . . Uhf/vhf data, seven-dual (polarization diversity)

Recorders, data . . 2 each, 14-track, 0-500 kHz fm record, or 400 Hz to 1.5 MHz, direct record (pre- and postdetection)

Timing . . . . . . Dual system, AMR/IRIG/NASA codes, atomic freq standard

Data transfer . . . 1 link uhf, 0.5 watt; 1 link vhf, 0.5 watt

TABLE 6-1. ARIA AND TRAP NOMINAL FLIGHT PERFORMANCE DATA

Parameter	Nominal Value*
Minimum take-off gross weight	285,000 lb
Minimum time to climb to 30k ft (GW 224,000 @ start climb)	24 minutes
Normal cruise speed	450 kt (true air speed)
Maximum cruise speed (@ 30,000 ft)	480 kt TAS
Nominal turning radius (30k ft) 420 KTAS, 20° bank)	7.0 nmi
Minimum turning radius (30k ft) (420 KTAS, 30° bank)	4.5 nmi
Nominal turning time, 180°/30k ft (420 KTAS, 20° bank)	3 minutes
Minimum turning time, 180°/30k ft (420 KTAS, 30° bank)	2 minutes
Nominal operating altitude	25,000 to 30,000 ft
Maximum operating altitude	40,000 ft
Range	**

* Committable flight performance must be developed for each specific mission, but the values given are suitable for planning.

** Application of geographic and climatic factors to 25 airports worldwide give maximum ranges of from 2,800 nmi to 4,500 nmi.

Voice relay . . . . Spacecraft to aircraft: Vhf/a-m – simplex and uhf-USB duplex;
Aircraft to ground: Hf-SSB, duplex (hf 1 kW, vhf 100 W, uhf 100 W)

Teletype . . . . . One 65-100 w/min page printers, 1 tape perforator, 1 tape reader

Acquisition system . . Automatic bar scan or manual using precomputed look angles.

Telemetry and timing system specifications are detailed in paragraphs 2.2 and 2.3.

6.1.1 Special Projects Instrumentation

From time to time, special mission support requirements result in the modification of the ARIA to install racks or consoles of special project instrumentation. These are palletized and designed to be installed on any of the ARIA.

The existing special project instrumentation subsystems are:

- Space Ground Link Subsystem (SGLS)
- Data Processing Subsystem (DPS)
- Unified Configuration Console
- Data Separation and Storage Buffer (DSSB)
- Data Separation Console (DSC)

TABLE 6-2. ARIA AND TRAP NAVIGATION CAPABILITIES

Navaid(s) Used	Circular Error (1)	Note
Inertial navigator (Carousel IV)	2 nmi/hr	2
Dual TACAN AN/ARN-21	4 nmi	3
Dual VOR/ILS (51R-6/51V-4A)	4 nmi	3
Dual ADF (DFA-70)	3 to 20 nmi	3
Loran (AN/APN-70)	7 nmi	3
Search radar (AN/APN-59)	5 nmi	
Beacon-equipped ship (DPN-66/APW-11)	10 nmi	4
Doppler (AN/APN-147V)	50/30 nmi	5
Celestial (periscopic sextant)	50/30 nmi	5

NOTES:
1. Committable navigation capabilities must be developed for each specific mission but the values given are suitable for planning.
2. Since last ground check point.
3. Dependent on range from station.
4. Assuming ship location is known to 2 nmi.
5. Day/night

The DSSB is a single rack of equipment designed so that it can be mated to a SGLS console to form a 3-bay console. This subsystem provides the capability to receive high bit rate PCM or PSK telemetry data, store selected words from the data stream, retrieve these words, and retransmit them via hf to a ground station in near real-time. The DSC incorporates the capabilities of the SGLS, DPS, and DSSB into a 3-bay console.

The ARIA have domes located in the top center line of the fuselage. Special TACSAT antennas are installed at this location when special TACSAT telemetry relay missions are scheduled.

6.1.2 Range Instrumentation Checkout

Aircraft beacons and simulators are primarily used to check out various ship and ground-based missile tracking equipment. For example, if a light on the aircraft is used in conjunction with ballistic cameras on the ground, then the aircraft position may be accurately determined optically. The accuracy of the radar tracking equipment may then be determined by comparing the radar data with the known accurate optical fix.

TABLE 6-3. ARIA SIGNAL TRANSMISSION CAPABILITY

Frequency Range (MHz)	Antenna	Transmitters	Comments
2090–2300	7-ft dish	2	Data and voice
2–30		3	Trailing wire and two probes
225–400	Dipole/blade	1	Satellite data communications

TABLE 6-4. ARIA SIGNAL RECEPTION CAPABILITY

Frequency Range (MHz)	Antenna	Receivers	Recorders
2200–2300	7-ft dish	6 @ 4.0 MHz	2 @ 1.5 MHz
750–1540	7-ft dish		
136–400	7-ft dish		
2–30	*	3	**
225/400	Dipole/blade	1	

NOTES: *One trailing wire and two wing-probe antennas.
**Voice transmissions are recorded on data recorders.

Additional uses of beacons and simulators include vectoring of an aircraft to a desired position for other test purposes, testing of antennas designed for use on missiles, simulations of manned or unmanned spacecraft, and simulations of drone operations. The airborne beacons most commonly used on the ETR are as follows:

DPN-66 Radar Beacon

Receiver:

Frequency: 5395-5905 MHz

Sensitivity: -70 dBm

Codes: 4 plus signal pulse

Transmitter:

Frequency: 5400-5900 MHz

Peak power: 500 watts

Power input: 28 V dc at 1.9 A

APW-11 Radar Beacon

Receiver:

Frequency: 2680-2920 MHz

Sensitivity: -45 dBm

Transmitter:

Frequency: 2700-2950 MHz

Peak power: 137 watts

6.2 TERMINAL RADIATION PROGRAM AIRCRAFT (TRAP)

The primary mission of TRAP is the acquisition and analysis of optical data in the ultraviolet, visible, and infrared portions of the spectrum for the evaluation of R&D reentry experiments. The aircraft has basically the same nominal flight performance (table 6-1), navigational capabilities (table 6-2), and communication capabilities as the ARIA.

TRAP AIRCRAFT

Special instrumentation tracking systems are mounted on both fixed and gimbal pedestals which use remote acquisition sights for manual and automatic tracking. These systems are:

- Dual-Channel Photometer
- High Resolution Camera System
- Framing Spectral Ballistics
- Cinespectrographs
- Metric Ballistic Camera Subsystems
- High Speed and Wide Angle Cines
- Master Tracking System
- Timing and Recording Systems

The operation, maintenance, and upgrading of TRAP instrumentation plus the processing and analysis of TRAP data is provided to Space and Missiles Systems Organization (SAMSO) by AVCO Everett Research Laboratory, Inc (AERL), Everett, Massachusetts. Details of the systems and operational mission support availability can be obtained from:

SAMSO/RSTFS
P.O. Box 92960
Worldway Postal Center
Los Angeles, California 90009
Autovon: 833-2870